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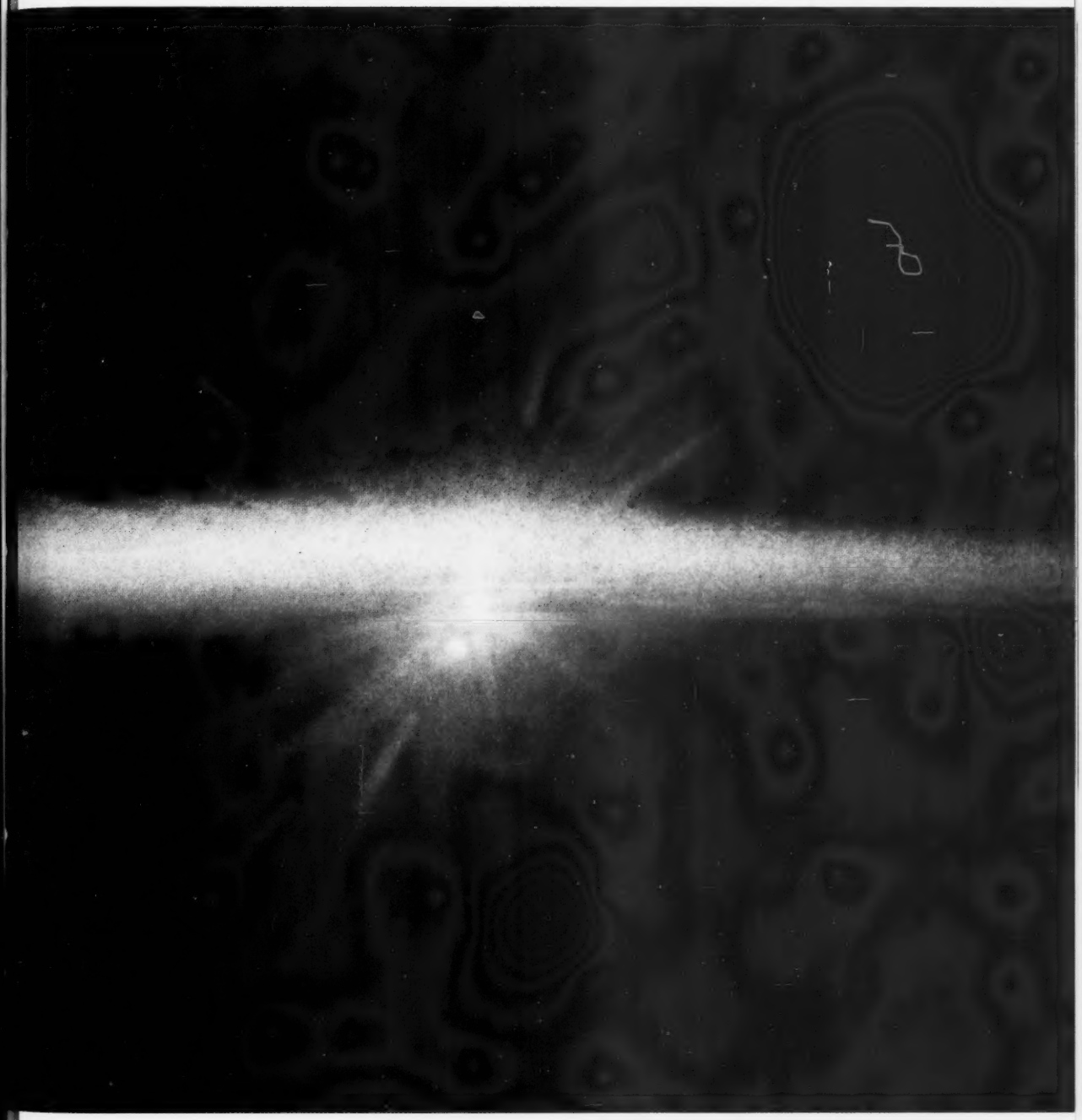
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

APRIL 1958



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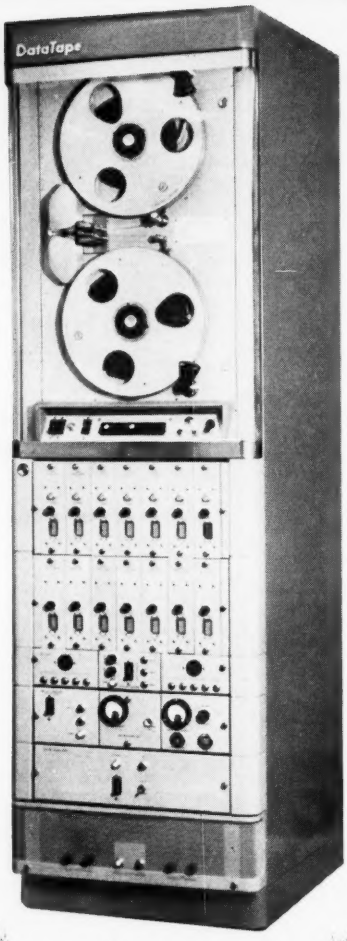

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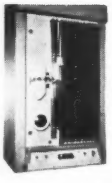

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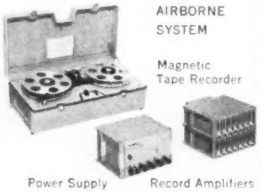

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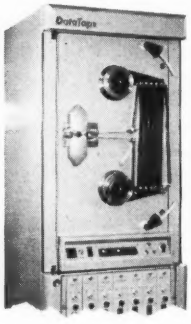

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April 1958 volume 3 number 4

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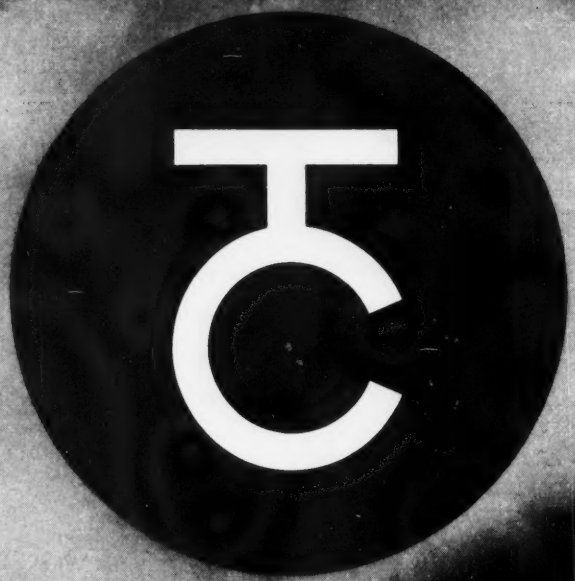

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astro notes

RESEARCH

• AEC lifted the security curtain briefly in early March to give newsmen a look at its new $11 million nuclear rocket and propulsion base at Jackass Flats, Nev. Efforts at the base will be devoted initially to AEC's Project Rover nuclear rocket engine and to the Project Pluto nuclear ramjet. . . U.S. satellite efforts will continue in high gear for at least the balance of this year, with a minimum of four satellite firings apiece scheduled by the Army and Navy. . . Meanwhile, top military brass expects Russia to attempt more animal-carrying satellite firings, recovery of a satellite payload and possibly of an animal, and perhaps even a moon shot this year. . . Aerojet's Aerobee family continues to grow. With Aerobee Junior successfully tested, the company is working on a larger version which will take an instrument payload to 300 miles, and also recently proposed a five-stage Aerobee M, utilizing Aerobee Senior solid propellant rockets developed for the Polaris program, for use as a moon rocket. . . The Administration has turned thumbs down on an AF proposal to speed development of the first nuclear aircraft for prestige purposes, deciding instead to concentrate on development of a military nuclear plane. . . The Soviet IGY Committee has reported launching 10 rockets in the Polar areas as part of its upper atmosphere research program.

MISSILES

• Static firings of Titan propulsion system got under way early last month at Martin's Denver plant. . . First Polaris test flight is set for this fall, with production scheduled to begin some time next year. . . Use of new GE Mark I nose cone in successful Feb. 28 Thor firing indicates program is entering its final test phase. . . Thrust of Rocketdyne engine used in both Thor and Jupiter is now given as 150,000 lb. Engine operates on RP-1 and lox, although minor modifications would allow use of Hydyne fuel employed in successful Explorer shot. . . AF has received go-ahead on its Minuteman multipurpose solid propellant weapon system, scheduled to become operational in 1962. The program envisages a three-stage system to be fired from underground launching sites, with all three stages making up an ICBM, second and third stages an IRBM, and the third stage alone a tactical missile with a range of 500 to 1000 miles. . . Main power source for AF air-to-surface Hound Dog, under development by North American for use on B-52's, will be the Pratt & Whitney J-52 turbojet engine. . . AF is showing increased interest in solid propellant ICBM's, feels state of the art has reached a point where success of such a program appears promising. . . Increasing attention is also being given to possible use of monopropellants in missiles.

SPACE FLIGHT

• Army, with successful Explorer shot under its belt, is expected to get the job of firing a moon rocket, possibly some time this year, with the Air Force, which also sought the assignment, being directed to concentrate on military vehicles and, primarily, a manned satellite. . . Appointment of Rear Adm. John E. Clark, former Navy Guided Missile Director, to the post of Deputy Director of ARPA, has been welcomed by missile men. Big question at the moment is who will be Technical Director of the advanced projects agency.

ABROAD

• British are planning a major cosmic ray experiment, utilizing a photographic emulsion trap slung under a high-altitude balloon, later this year. The balloon, expected to reach an altitude of 100,000 ft, will be released either in Bristol, England, or Padua, Italy. . . Soviet physicist Kiril Stanyukovich has claimed progress in anti-gravity research and formulated a new mathematical expression of the laws of gravity. On the basis of his formula, Prof. Stanyukovich concludes gravity is not a constant force but depends on temperature, and suggests there would be a considerable lowering of gravitational force as temperatures approach absolute zero. . . European scientists, mindful of announced Soviet intention to fire a satellite each month during IGY, are speculating that the Russians have also run into snags in launching additional baby moons.

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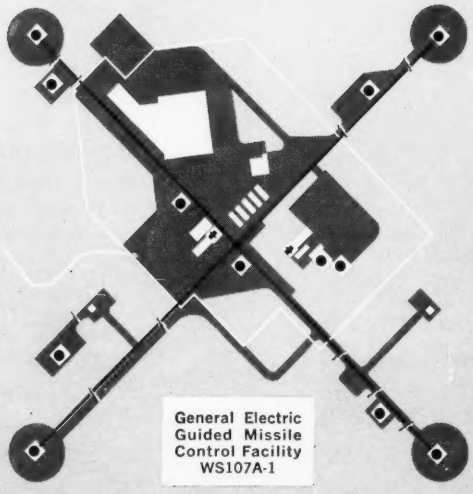

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SPACE FLIGHT

• It will be late Spring or early summer before the new Advanced Research Projects Agency has much impact on the space program. Roy W. Johnson, the new director, won't be on the job full-time until April, and it will be some time before his organization is fully staffed. Johnson hopes to keep his staff to a minimum, perhaps as few as 50, but Pentagon skeptics doubt that he will.

• NACA, slapped down hard by a House appropriations subcommittee, is relying on the Senate to rectify what many capital observers consider an injustice. Apparently the House subcommittee took it as a personal affront when NACA witnesses did some straight talking about past niggardliness by the U. S. in the financing of basic research.

NACA's hopes for success in its bid for control of nonmilitary space research probably rest with Dr. James Killian, the President's top scientific adviser. Although he hasn't committed himself, Killian is believed favorable to the idea of building NACA up instead of creating an entirely new space agency.

CONGRESS

• Assistant AF Secretary Horner told Congress development contracts for a rocket engine of a million pounds thrust have been signed recently. He also talked about a million-and-a-half pound engine, but this would be a manifolding of five 300,000 lb engines.

• Defense Secretary McElroy told Congress he would seek a fiscal 1959 supplemental—probably about $2 billion—before adjournment of the present session. Increased production of manned bombers will be a big item, but more missile money is also needed. Within a few months, the AF will have firmer plans for ICBM bases, need substantial funds to obtain real estate and start building.

MISSILES

• AF is doggedly pursuing the ultimate cancellation of Jupiter. Officials believe that with Thor now well proved, whatever excuse there was originally for the decision to produce both missiles no longer exists, and that money and effort will be wasted if a dual program is allowed to run for very much longer. Fact that British are coming along with their own IRBM may strengthen AF's point.

• There's a chance the Army will reorganize its missile and rocket center at Redstone Arsenal. The high priority Jupiter program, and fact that Navy interests were initially involved, were original reasons for keeping the Army Ballistic Missile Agency separate from Redstone Arsenal itself. Now, however, there's some sentiment for merging the two. Result could be an Army Missile Command. It's argued that this would not only simplify administration (notably in public relations matters), but make it more difficult for the von Braun team to be taken away from the Army.

• Officials seem cool to the persistent efforts of air-breathing missile partisans to have these weapons—Snark, Regulus, Matador, etc.—produced in larger quantities. The argument is that until ballistic weapons are perfected, and perhaps even afterward, the air-breathers offer an effective and relatively economic means to saturate enemy air defenses from overseas bases.

• AF is reported considering a new air-to-ground, air-breathing missile fabricated largely in plastic to make it a difficult target for radar. Developed by Fairchild, missile, known as Gander, is reported inexpensive enough to be produced in large quantities.

• It's now doubtful that Polaris will be put on Navy aircraft carriers, as once proposed, but other surface ship applications are under consideration. One possibility: A fast, nuclear-powered cruiser whose main armament would be Polaris, with Talos added for air defense.

RESEARCH

• James Killian, science adviser to the President, has gotten his message across to the President at a Cabinet meeting concerning the urgent need for increasing research in meteorology, nuclear physics, geophysics, oceanography and space. He's been ordered by the President to set up a multi-million dollar program to purchase scientific instruments for space and nuclear research at universities and other institutions.

Dr. Killian will ask for an initial $50 million for a program to improve weather forecasting by utilizing data obtained from the Explorer I.

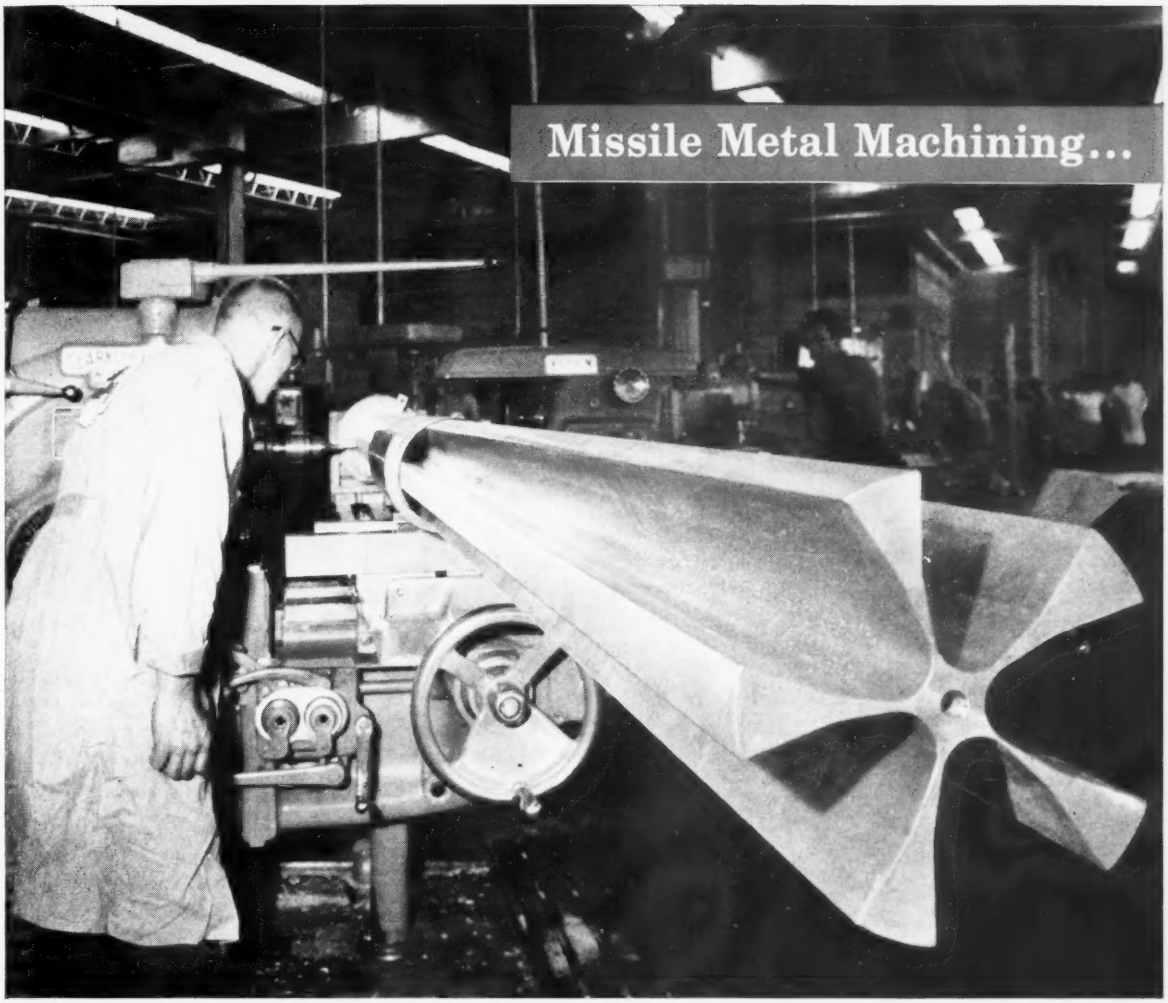
PENTAGON

• Pentagon has been discussing with leading editors the possibility of arranging a press agreement similar to that in operation at Cape Canaveral. There, reporters are privy to virtually everything that goes on, including choice vantage points to view all missile firings, but do not reveal certain information until officials grant permission.

• Reorganization of the military establishment, on which action is due shortly, may go a long way toward eliminating some of the administrative hierarchy defense contractors have complained about. Although basic changes in the Joint Chiefs and elsewhere in the military staffs is unlikely, there's widespread agreement that the tangle of civilian chiefs in Pentagon has got to be thinned. Best bet: Fewer assistant secretaries, both in the services and on the Department of Defense level, and more power for the Defense Secretary himself.

NUCLEAR PLANE

• Fate of the 12-year-old atomic-powered plane project rests in the hands of James Killian, science adviser to President Eisenhower. He is organizing a special staff to review the controversy over which some $500 million has already been spent. The Air Force and Navy have been rivaling for permission to produce the nuclear plane.



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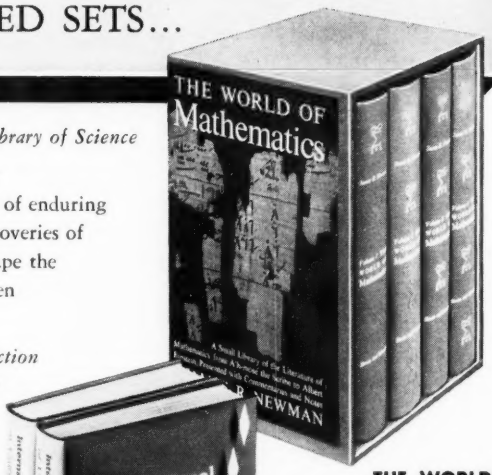

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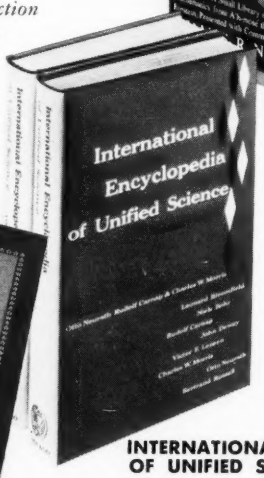

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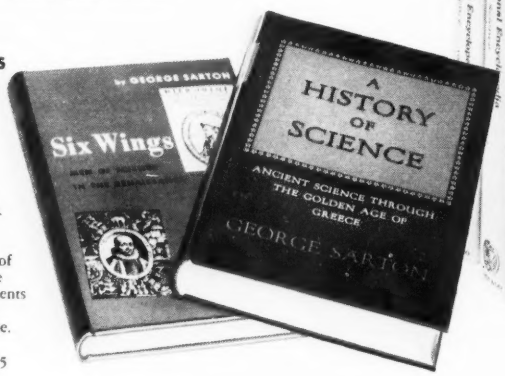

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In July, 1957, Russia once more rang a bell, not for the conditioning of a dog, but for the entire world. The clang of the bell, in this case in the form of an official statement by the Soviet Union to IGY Headquarters read: "The program of the U.S.S.R. for the IGY includes studies of the atmosphere of the earth by launching rockets and man-made satellites."

We in the field of rocketry will never forget that day in October when the forewarning of the bell came true, in the form of Sputnik I.

"Luck" was the typical comment of the "man on the street," but the fallacy of this form of thinking was proved by Russia when she once more rang the bell with Sputnik II.

Several times since the Soviets have rung the bell with such statements as "Superfuels," "Russian rockets on the moon soon," etc.

With all due credit to Russia on her great accomplishment in launching the world's *first* man-made satellite, we still can not allow our mouths to water, nor our digestive juices to squirt, every time a bell is rung. Instead, we must put our shoulders to the wheel, so to speak, and believe that "defeat may serve as well as victory, to shake the soul and let the glory out."

Domingo Losa
21007 Le Fever
Warren, Mich.

More "Ayes" on Upton Proposal

Dear Sir:

I was about to write suggesting ARS sponsorship of a nongovernmental rocket program supported by public subscription when Mr. Upton's letter in the January issue came to my attention. . . . My reaction is: Bully!

From any point of view, including public relations, as Mr. Upton notes, this is a "natural." A special type of ARS membership might be set up, open to both qualified rocketeers and the general public, involving contributions to be used for system and hardware development. A few bucks each from a few million interested people would net quite a kitty. A number of ARS members who are well plugged in on current states of the various arts might be induced to serve as consultants. Contracts could be let to various missile and aircraft firms. When the amount of financing available is known, the specific program to be undertaken (around the moon, or whatever) could be cut to fit.

An incidental benefit would be the opportunity to channel off some of the lethal teen-age enthusiasm for homemade bombs into a useful effort. Let 'em join ARS instead.

W. F. Janeway
Santa Barbara, Calif.

Dear Sirs:

I heartily agree with the proposal advanced by Mr. Richard E. Upton in the January "Feedback" column. Such a project would not be hampered by politicians or others, as it would if it were a government project. Also, since it would be separated from the defense effort, it would not be held back by priorities.

If ARS were to take on a project of this kind, I believe it would improve U.S. chances of reaching outer space or the moon first. . . .

John Rech
1921 Linden St.
Brooklyn 27, N.Y.

Reprint Requests

Dear Sirs:

It is requested that this school be given permission to use all or parts of articles, appearing in your November and December 1957 issues of ASTRONAUTICS, entitled "Problems of Launching an Earth Satellite."

These articles are to be used in the preparation of a manual, entitled "Orientation Manual for Guided Missiles," for use by students and agencies of the Ordnance Guided Missile School, Redstone Arsenal, Alabama.

Col. H. S. Newhall
Commandant
U.S. Army Ordnance
Guided Missile School
Redstone Arsenal, Ala.

Gentlemen:

The Academic Staff of the Air War College has recommended as selected reading for the students, an article entitled "Rockets and Satellites" IGY 1982–83 which appeared in ASTRONAUTICS, October, 1957 issue.

Request your permission to reprint this article in 185 copies to be used only within the school's activities.

Appropriate credit to the author and magazine will appear on the cover sheet of each copy.

Col. J. B. Wells
Deputy for Administration
Air University, Air War College
Maxwell AFB, Ala.

Both of the above reprint requests have been granted—Editor.

More on Moon H-Blasts

Dear Sirs:

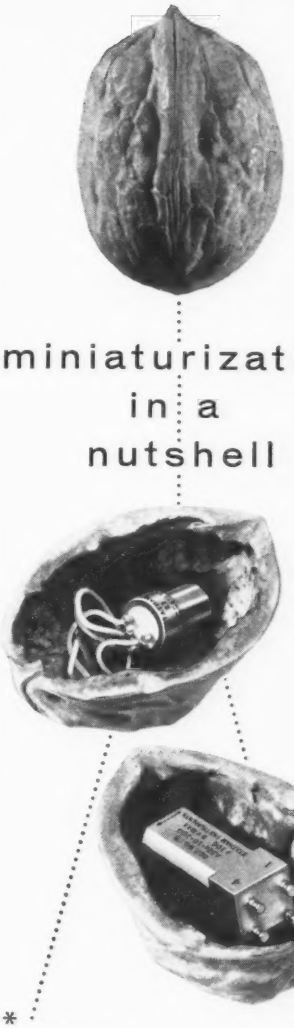
I found your treatment of my comments on the proposal to explode H-bombs on the moon very good except for one important omission on the subject of Foucault's pendulum (January ASTRONAUTICS, p. 78).

"In any case, it should be clear that the turning of Foucault's pendulum represents that rotation which, energetically, corresponds to a zero rotation and which, for example, can give no centrifugal force."

I should also like to add that my personal opinion is that the earth will keep its rotation unaltered, whatever the increase caused by H-bombs in the distance between the moon and the earth.

However, I still feel the problem should be carefully studied *before* the first H-bomb is sent to the moon.

ROBERT ENGSTROM
Skeppergatan 19
Stockholm, Sweden



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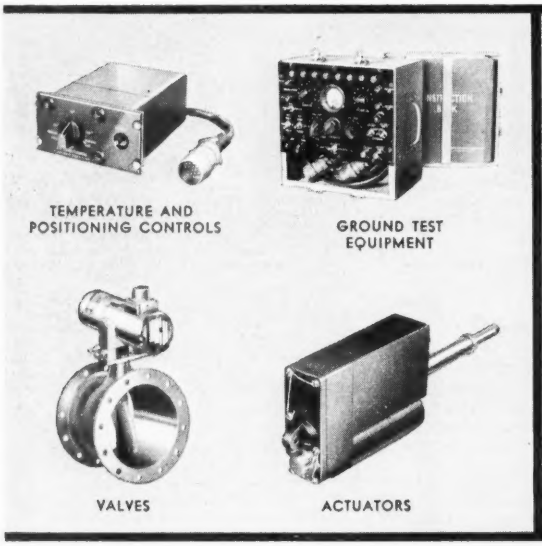

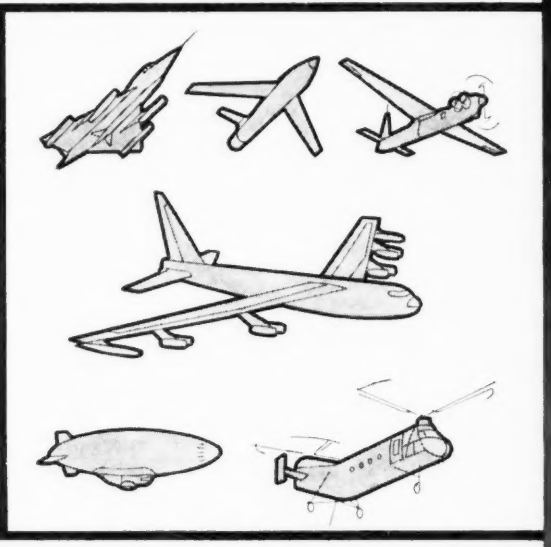

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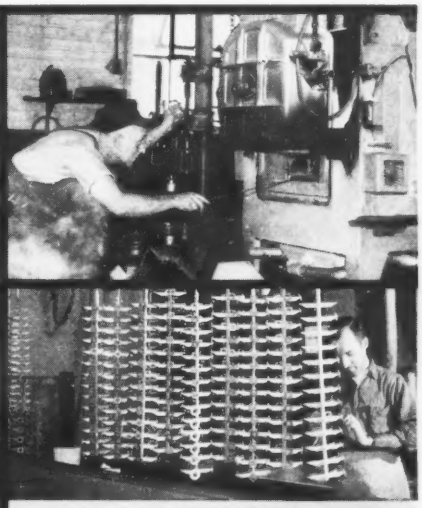
Complete follow-through from product development to product application . . . is standard procedure on every piece of aircraft equipment that bears the Barber-Colman mark. Every step of engineering, manufacturing, and testing is performed under the complete control of "one maker." For example, control system components such as motors, relays, gears, pinions, valves, sensing elements, and the like, are of Barber-Colman Company's own manufacture. Metals are analyzed, treated, and finished in our own departments. Machining and gear hobbing are performed on machines of our own make. A few typical scenes from the vast Barber-Colman development and manufacturing areas are shown below.

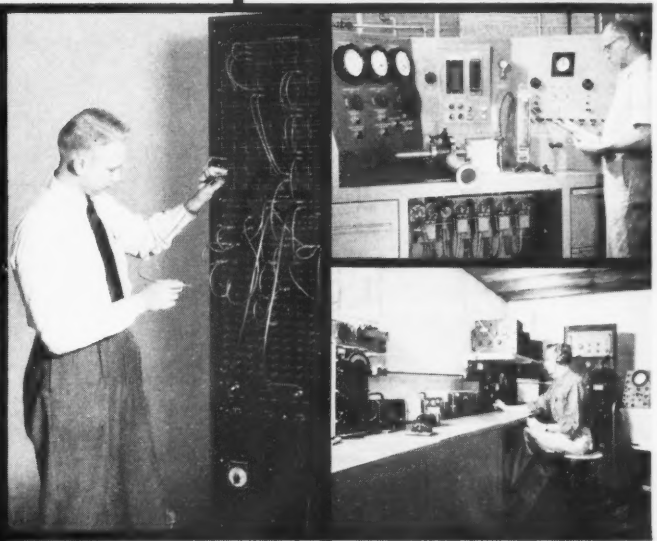
ENGINEERING —Barber-Colman Company with its highly experienced staff of engineers is able to bring you specialized assistance at any stage of your controls development program.

METAL-TESTING —Skilled technicians in well-equipped chemical and metallurgical laboratories maintain constant surveillance of materials . . . analyze and determine exact heat-treatment needed.



HEAT-TREATING AND METAL-FINISHING —Batteries of furnaces, ovens, and immersion pots are at hand for all types of heat-treating. Finishing includes anodizing, alodizing, sand-blasting, vapor-blasting, electropolishing.

FROM PROTOTYPE TO PRODUCTION —Barber-Colman Company maintains its own fully equipped and expertly staffed department for complete manufacture of prototypes (top view). Lower view shows a section of the actuator production operation.



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for the record

The month's news in review

***March 17*—At press time, the Navy announced it had successfully placed a Vanguard satellite into orbit early this morning. Good news after two previous failures.**

Feb. 3—Senate unanimously okays $1.4 billion for missiles, air bases and detection systems.

—Army missile experts ask official okay to launch two reconnaissance satellites weighing between 300 to 700 lb before year's end.

—Defense Dept. releases funds for advance planning of satellites heavier than 30.8-lb Explorer.

—New Joint Congressional Atomic Energy Subcommittee on Space Propulsion holds first meeting, deals with peaceful conquest of space.

—Cal Tech scientists reveal initial data from Explorer indicates cosmic rays and meteoritic dust are not hazards to space travel.

Feb. 4—President orders his scientific adviser James R. Killian Jr. to make a special study to resolve the conflict of civilian versus military control over outer space activities.

—Retiring Army R&D Chief Lieut. Gen. James M. Gavin tells congressional panel that U.S. should build defense for "satellite intrusion."

Feb. 5—Navy Vanguard destroyed shortly after launching.

Feb. 6—NRL says Vanguard failure was caused by wiring defect.

—AF fires a Mace missile 650 miles.

—Senate sets up temporary committee to chart legislation on outer space programs.

Feb. 7—Defense Dept. appoints Roy W. Johnson, vice-president of General Electric, chief of Advance Research Projects Agency.

—Atlas destroys itself after powered phase of its flight.

Feb. 8—AF briefing officer says rocket can be sent to moon this year.

Feb. 9—Airman begins week-long simulated trip to moon at School of Aviation Medicine, Randolph AFB.

Feb. 10—Navy discloses new anti-sub weapon called Rat (for Rocket-Assisted Torpedo).

Feb. 11—Army successfully test-fires a Redstone missile.

—Army announces major advance in Plato, mobile, anti-missile missile.

Feb. 12—Successful firing of Japanese plastic body rocket reported.

—One Explorer radio silent after 11 days.

—AF orders activation of first Atlas squadrons by April 1.

Feb. 13—Nike-Cajun fired to test auroral effects as part of IGY program.

Feb. 14—Navy names two companies to build three nuclear-powered Polaris missile submarines by 1960.

Feb. 16—Airman successfully ends seven-day simulated flight to moon.

—Soviet news agency reports Russians are training a dog for a third satellite.

Feb. 18—AF fires Mace 600 miles.

—3000-lb AF reconnaissance test satellite, part of Pied Piper project, is planned for October shoot.

—Soviet may launch satellite a month for rest of 1958, according to House Appropriations Subcommittee report.

Feb. 19—Record air-flow speed of 32,400 mph attained in AF wind tunnel test.

Feb. 20—SAC names WS-110A supersonic intercontinental bomber the B-70.

—Atlas explodes two minutes after launching.

—AF criticizes Defense Secretary McElroy for choosing Army to develop anti-ICBM weapon.

Feb. 24—U.S. and England sign 5-year agreement under which U.S. will supply 60 AF Thors for British bases.

Feb. 25—AF R&D chief seeks quick go-ahead on programs to send rocket to moon and put manned satellite in orbit at "early" date, predicts Russians will try four satellite launchings in next six months.

—Navaho loses its engine seconds after launching and is destroyed in last test.

Feb. 27—Defense Secretary McElroy tells Senate Preparedness Subcommittee that Administration will ask Congress for additional $1.3 million for ballistic missiles and space weapons, and perhaps a rocket to the moon project.

—AF's Minute Man Project to produce 500-to-5500-mile ballistic missile that can be launched from underground installations is approved by Missiles Director Holaday.

—Navy expects Polaris to be ready for use in specially designed nuclear submarines by 1960.

—First British-manned Thor squadron is slated to be in operation by Dec. 1958.

Feb. 28—First Thor capped with new re-entry cone is fired by AF, keeping program ahead of tight schedule. Larger version of the nose cone has been designed for the Atlas ICBM.

—Defense Dept. orders AF to develop long-range missiles powered by solid-fuel propellants.

WHY DOUGLAS ENGINEERS AND SCIENTISTS GO FURTHER . . .

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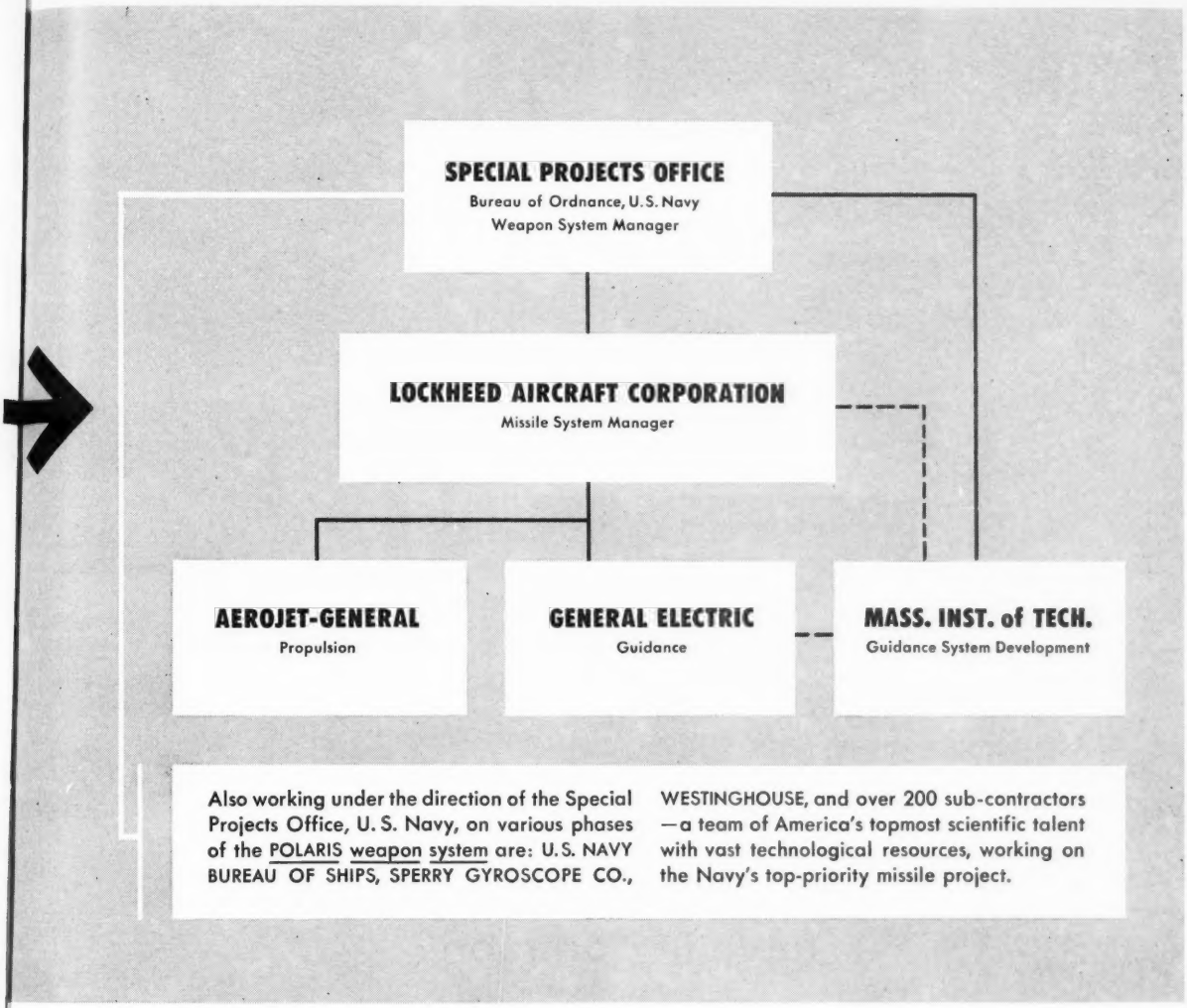
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Guidance System Development
Also working under the direction of the Special Projects Office, U. S. Navy, on various phases of the POLARIS weapon system are: U.S. NAVY BUREAU OF SHIPS, SPERRY GYROSCOPE CO., WESTINGHOUSE, and over 200 sub-contractors —a team of America's topmost scientific talent with vast technological resources, working on the Navy's top-priority missile project.

Fourteen months ago Lockheed was appointed missile system manager of the POLARIS. The objective: to develop a solid-propellant missile with a thermonuclear warhead, which could be launched underwater from nuclear submarines to hit targets 1,500 miles away. The technological problems involved were admittedly the most complex yet encountered in the history of ballistic missile development.

Progress to date on the POLARIS has exceeded all expectations of the U.S. Navy. Lockheed is proud to be associated with its fellow task force members and the sub-contractors developing the complete POLARIS weapon system. The brilliant contributions and splendid teamwork of these more than 200 POLARIS subcontractors, and their dedication to our mutual goal—greater security for our nation—speeds the progress of the POLARIS missile system, prime responsibility for which is Lockheed's.

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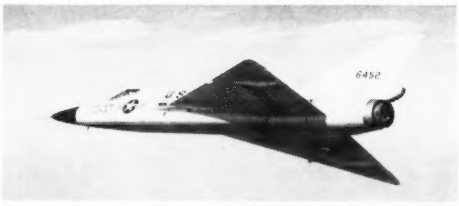

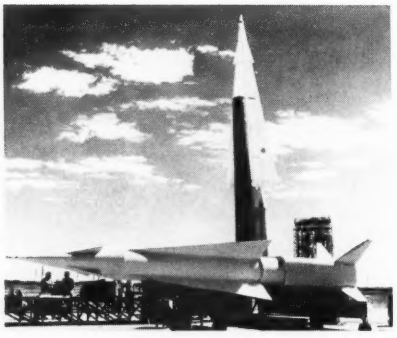

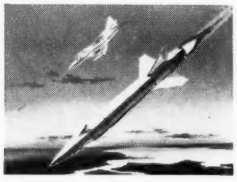

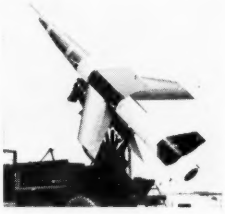

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All are equipped with Genisco flight control or instrumentation accelerometers. What better proof of reliability?

With component reliability getting increased attention from missile and aircraft designers, it is significant to note the number of supersonic weapon systems equipped with Genisco accelerometers.

A complete list reads like a roll call of tactical and strategic missiles and aircraft now in the nation's arsenal. Included are such weapons as the *Atlas, Thor, Nike Ajax, Nike Hercules, Bomarc, LaCrosse, Bull Pup, Talos, Dart, Matador, Corporal* and *Terrior* missiles; and the F100D *Super Sabre,* F101 *Voodoo,* F106A, and Canada's CF105 aircraft. What better proof of the reliability of Genisco instruments than this acceptance by designers of these weapons?

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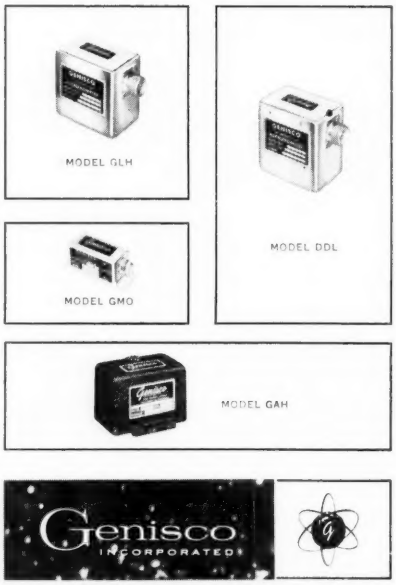

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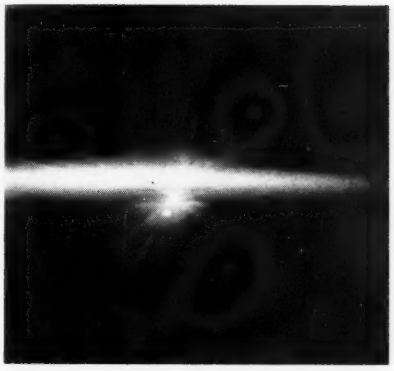


COVER: *The sunrise from 80,000 ft. This magnificent photo, taken by Maj. David G. Simons during his 24-hour Manhigh II balloon flight, symbolizes the grandeur that faces man as he makes his way into space.*

Astronautics

APRIL 1958

Space Flight—Talk or Action

What have we done in the United States about space flight since Sputnik was launched nearly five months ago? The answer is: Not very much. Yes, we have accelerated several ballistic missile programs and restored some of the budget cuts so that our military appropriations are approximately at the levels they were over a year ago. We even permitted the Army to complete and launch the "Explorer," a project which was administratively throttled for two years.

We have not lacked ideas or plans for space flight. The AMERICAN ROCKET SOCIETY was the first organization to submit such a program (last October) to our Government (see ASTRONAUTICS January, 1958, p. 21). It originated specific objectives, suggested time schedules, and outlined potential benefits and reasons. Other capable agencies, companies and committees have since formulated such plans, both from a general point of view and for special space flight projects. In addition many specific proposals have been generated by private companies, military organizations, nonmilitary government agencies, and various committees. Almost all the proposals are being held in abeyance or in the files of some government office. The ARS is not aware of any recent new major space flight efforts that have been undertaken up to March 1, when this was written.

We wait while Congress and the Defense Department discuss how this space flight effort should be organized and financed, and who should run this U. S. program. There are at least eight committees and subcommittees in Congress who are all actively concerned with this issue, and who are investigating these matters by holding hearings and sending people across the country as a sounding board. Several legislative bills are up for consideration. And it will be several more months before Congress will conclude these deliberations. Inside the Defense Department there are not only interservice jealousies as to the missions of the Army, Navy and Air Force in space flight but also strong rivalries between the organizations within the three services, and then there are several boards and committees debating this issue.

A new space flight organization called the Advanced Research Projects Agency recently has been created within the Pentagon; even though this agency does not officially start functioning until April, it has already been severely limited in what it will be allowed to do. It is doubtful that much will be done (CONTINUED ON PAGE 64)

Astronautics Report

Explorer I

Prepared by Jet Propulsion Laboratory for ASTRONAUTICS, this special article provides complete details on Explorer launching vehicle and instrumentation, describes flight mechanics used to orbit satellite

ON NOVEMBER 8, 1957, the Secretary of Defense announced that the Army was to participate in the International Geophysical Year Satellite Program. Just 80 days later, Explorer I was designed and placed in orbit through the cooperative efforts of the U.S. Army Ballistic Missile Agency and the Jet Propulsion Laboratory, California Institute of Technology. It is now a matter of history that at 5 sec past 10:55 p.m., E.S.T., on January 31, 1958, Explorer I was injected into orbit.

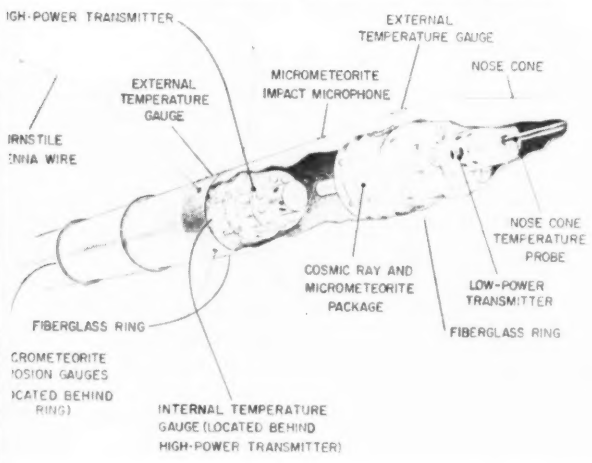
The story behind Explorer I dates back to May, 1955, when the Jet Propulsion Laboratory had been asked by the Army Ordnance Corps to assist Redstone Arsenal in the preparation of a feasibility study for a rocket vehicle capable of orbiting a small payload around the earth. The JPL study was presented to the Army on April 13, 1956. At this time, as part of a re-entry study program, the Missile Laboratories at Redstone Arsenal (now the Army Ballistic Missile Agency) were in the process of developing a modified high-performance version of the Redstone missile. This modified missile, together with additional solid propellant stages (the Jupiter C) as proposed by JPL, formed the Army's proposal for a satellite vehicle.

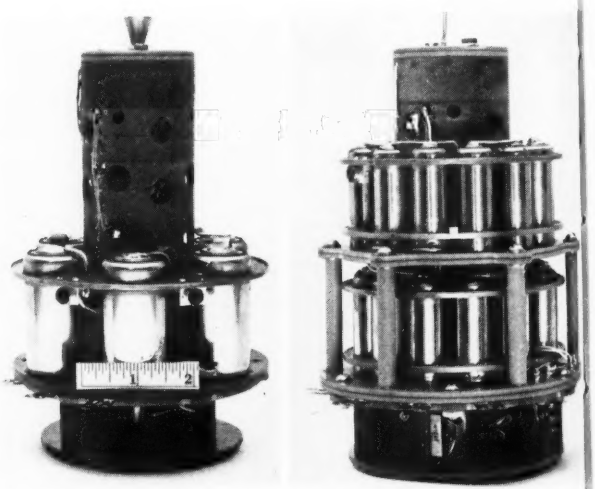
The solid propellant stages proposed by JPL had the following important characteristics: The re-entry test missile consisting of a modified Redstone missile plus solid propellant high-speed stages. For the orbiting mission, a propulsion stage and payload could be added to the re-entry missile without any important modifications to either the Redstone or to the high-speed stages.

On the basis of study results, the Laboratory proposed a communication system for determining the trajectory of an orbiting mass, using the newly developed Microlock radio techniques.

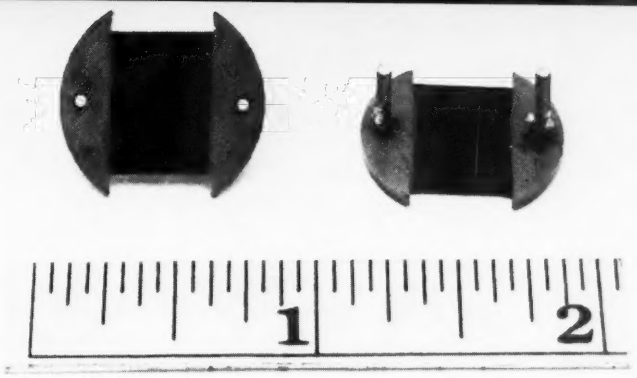
The payload section of the Explorer I satellite contains several types of instrumentation for making scientific and environmental measurements. Minimal radio transmitters were developed and built for tracking the orbital vehicle and for tele-

JPL-ABMA EXPLORER I SATELLITE





Low-power transmitter (left) and high-power transmitter (right) used in Explorer I.



Wound-wire grid used for measurement of micrometeorite erosion.

metering scientific information. Two types of environmental measurements were made: Temperature, and the frequency of collision with meteoritic material. Of a more purely scientific nature, the measurement of cosmic ray density was also made.

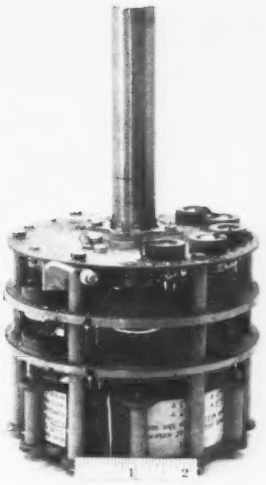
Due to difficulty in trying to determine how to prepare the outside skin of the satellite in order to achieve proper temperature control, an actual measurement of temperature in the orbiting vehicle was desirable. The actual temperature assumed by the electronic components depended not only on the surface temperature history throughout the orbit, but also on the thermal conducting paths between the instrumentation and the outside. In view of this, it was desirable to measure temperature at several points both inside and outside the orbiting payload. Temperature information was of vital importance for the proper design of future satellites.

Instruments Measure Cosmic Debris and Radiation

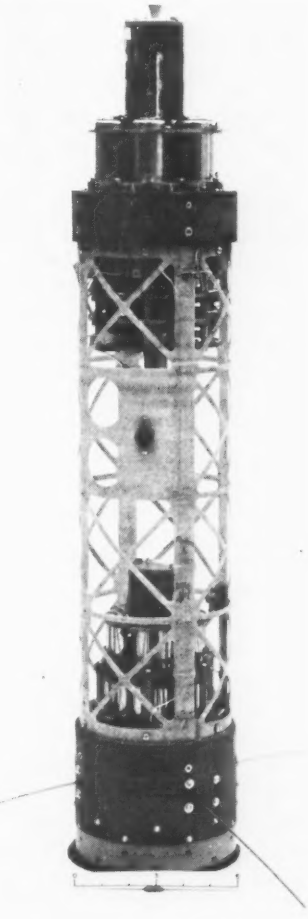
Erosion by cosmic debris was also under an environmental category. This measurement was made in two ways: First by means of an impact microphone which registered collisions occurring anywhere on the outside of the satellite payload. The microphone experiment indicated the frequency of impact by particles possessing more than a certain minimum momentum. Second, the system of grids composed of very small wires wound on a core was installed for the purpose of measuring impacts by meteoritic particles greater than a certain minimum size. The meteorite experiment was designed by M. Dubin of the Air Force Cambridge Research Center.

A geiger counter and associated scaling circuit were also included in the Explorer payload for the purpose of measuring cosmic radiation and transmitting this information back to the earth. The measurements were all made continuously and simultaneously, and no type of information storage device was used. Information has been gained by the satellite being picked up directly by ground stations during actual satellite passages. The cosmic ray experiment was designed by James A. Van Allen of the State University of Iowa.

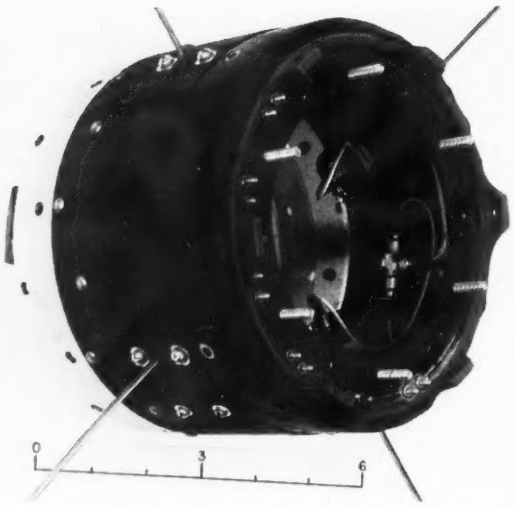
The first stage of the Explorer's launching system consists of a modified Redstone missile developed by ABMA, Huntsville, Ala. The Redstone was used to carry the high-speed rocket stages and the payload to approximately the final orbital altitude. It also contains a special attitude control system in its instrument compartment at the forward portion of the missile. The electric motors used to spin



Geiger-Mueller counter used in Explorer I Satellite for measurement of cosmic ray intensity.



View of Explorer I payload showing instrumentation arrangement.



Fiber glass cylinder used as connecting link between Explorer I payload and final-stage motor.

the high-speed motor assembly were also in this compartment. The Redstone propulsion system was modified from the standard in order to use a higher performance fuel than is normally utilized. The tank section was lengthened somewhat in order to obtain higher over-all performance from the vehicle.

The high-speed stages for the Jupiter-C missile were built from clustered solid propellant rocket motors which had been developed for use in the testing of various solid fuels and motor geometries. Because of the amount of experience that had been accumulated with these motors, JPL decided upon their use for the high-speed stages. Various arrangements of these motors were studied with the idea of obtaining maximum efficiency for the vehicle under consideration. It was undesirable to make any changes in the basic design of the motor itself since they had been successfully proved at the Laboratory in their present form. The high-speed stages were therefore made from clustered assemblies of these motors. For orbital use, the re-entry nose cone was replaced by a single rocket motor carrying the scientific payload on its forward end. The entire assembly of the high-speed stages was carried inside of the "tub." The tub was attached to a large shaft connecting it with the spin motors in the Redstone instrument compartment. The entire assembly, including the tub, was spun to minimize dispersion during the burning of the high-speed stages. The clusters of motors were fastened together by means of bulkheads. The stages were simply set one inside the other, and a series of launching lugs and sockets were used to maintain the close tolerances required for proper operation.

The instrumentation part of the payload was carried inside a cylindrical section made from stainless steel. This cylinder was rigidly attached to the forward portion of the final-stage rocket-motor case by means of a short cylinder of fiber glass which electrically and thermally insulated the payload itself from the rocket-motor case. The forward end of the payload was covered by a nose cone which was designed to minimize aerodynamic heating during the launch phase. The thrust loads were carried in the cylindrical section of the payload, which had been machined very carefully in order to preserve balance of the entire payload through the assembly and checkout operation.

The payload components were mounted on micarta boards for the purpose of providing thermal insulation from the outside shell. The temperature excursions of the outside shell were expected to be severe as the satellite went from full sunlight to the full shade of the earth. The surface coating was prepared in such a manner that the weighted mean temperature of the outside surface would be around room temperature. The structure holding the payload electronic components was then designed to have minimum thermal conductivity. This took the form both of using minimal amounts of material consistent with structural integrity and of using materials known to have a low thermal conductivity.

Techniques for Temperature Control

The approach taken to predict the external temperatures under orbital conditions was from an experimental and theoretical standpoint. Two techniques for temperature control were considered. One of these involved the surface preparation of the orbiting section of the vehicle to balance the high temperature experienced in direct sunlight against the low temperature resulting when the satellite is shielded from sunlight. In this connection, the electronic components were thermally insulated from the exterior in such a manner as to reduce the wide temperature excursions. The second method involved the use of heat switches which would

Standard Subcarrier Channel Assignment for FM/FM Telemetry

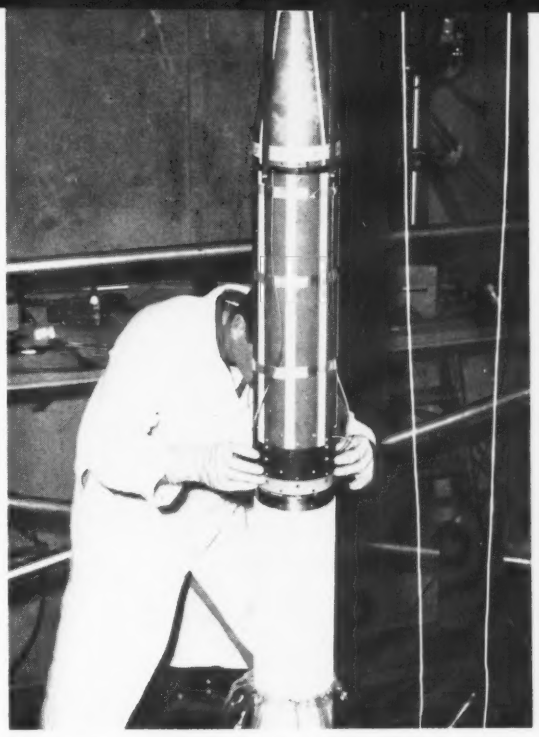
Channel No.	Low-Band Limit cps	Band Center cps	High-Band Limit cps	Total Bandwidth cps
2	518	560	602	84
3	675	730	785	110
4	888	960	1032	144
5	1202	1300	1398	196

mechanically open and close, depending on temperature conditions, to allow heat to flow into or out of the instrumentation section. The heat switches would operate in such a manner that the actual temperature of the instrument would be largely independent of the temperatures experienced by the outside skin. This latter approach was discarded because it was believed to be a system of low reliability in its present state of development.

Deciding Actual Shape of Payload

The control of temperature by means of surface preparation appeared to have a greater flexibility although much of the orbiting environment, of course, was unknown. Early considerations based on high- and low-temperature surface emissivity indicated that a cylinder of bare heat-treated stainless steel would provide a relatively high temperature, and that a cylinder of high reflectivity (such as aluminum oxide) would provide a low temperature. The proper balance between these two extremes could be obtained by judicious selection of the ratio of the areas of bare steel to aluminum oxide. Since the payload proper did not have spherical symmetry, its orientation with respect to the sun was significant. The firing time and date had to be consistent with the surface preparation in order that the proper aspect angle with the sun might be achieved.

The actual shape of the payload depended upon several considerations. Some consideration was given to making the payload in the form of a sphere. However, the sphere presented several design problems. It was felt the sphere could not be made sufficiently rugged to survive the launching through the atmosphere. A weight penalty was involved either in making a sphere that would withstand aerodynamic load or in covering the sphere with a shielding cone to protect it from the atmosphere. The use of a cone would further decrease the reliability of the over-all system since the discarding must be done in a proper manner. The use of a cylindrical payload was consistent with the vehicle itself (shape and size of the final-stage rocket motor) and with the instrumentation that was to be carried. The argument that a sphere should be used because of its constant frontal surface from the standpoint of the determination of upper-atmosphere density was not considered justified. If a sphere is used which has protruding rod-like antennas, then spherical symmetry is no longer maintained because these antennas are expected to interact electrodynamically with ionized gas molecules in such a manner as to produce enhanced drag in certain preferred directions. The fact that the payload was spun dictated that the electronic com- (CONTINUED ON PAGE 83)



View of Explorer I showing Rokide protective coating.

Summary of Performance Characteristics for the First Experiment

Characteristic	Low-Power Transmitter	High-Power Transmitter
Transmitter power	10 mw	50 mw
Transmitter frequency	108.00 mc	108.03 mc
Antenna type	Dipole	Turnstile
Maximum effective antenna gain	−2 db	+1 db
Maximum effective radiated power	+8 dbm	+18 dbm
Radiation polarization	Linear	Circular
Type of modulation	Phase	Amplitude
Amount of modulation (total of four subcarriers)	0.7 radians rms	50 per cent
Subcarrier frequencies (standard FM/FM channels)	2, 3, 4, 5	2, 3, 4, 5
Measurement by channel assignment		
Channel 2 (560 cps)	Skin temperature, forward	Skin temperature, rear
Channel 3 (730 cps)	Nose cone	Internal temperature
Channel 4 (960 cps)	Wire grid micrometeorite detection	Microphone-amplifier micrometeorite detection
Channel 5 (1300 cps)	Cosmic ray count	Cosmic ray count
Expected life	2 months	2 weeks

Who's who in missile contracting

Department of Defense provides listing of prime contractors and major subcontractors, unveils new Army, Navy and Air Force weapon projects

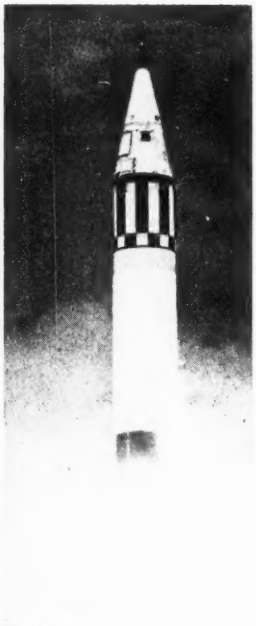
THE PRESS (and the public) got a close look at the U.S. guided missile program via a special briefing conducted by the Defense Department early in February. In addition to reviewing the present state-of-the-missile art and listing prime contractors and major subcontractors, briefing officers offered this preview of things to come:

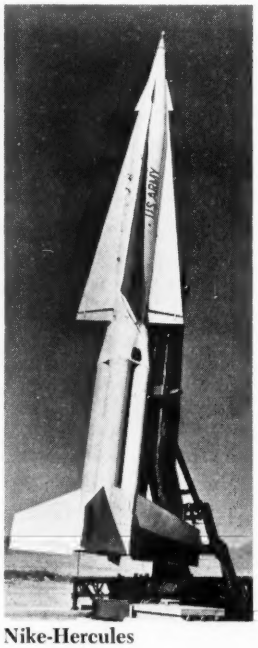
ARMY—The Army considers an anti-missile system feasible, and **Nike-Zeus,** its candidate, is now an actual development program in the hardware stage, and not a study program. Also revealed for the first time were some details concerning the **Sergeant** (see page 58) and the **Little John** lightweight free rocket, designed as a sister weapon for Honest John. The Army also pointed to three major assets: Top development teams, established operational and logistic missile bases, and trained men and a going training establishment.

NAVY—The Navy reported on its **Tartar** surface-to-air missile, a smaller brother of the Terrier, designed for use from ships as small as destroyers and for secondary battery use from cruisers; and on **Bullpup,** an air-to-surface missile for use by light attack aircraft in close air support and interdiction missions, which will be introduced into the fleet this year. Also noted was the fact that the Navy already has five missile units in its operating forces, and that squadrons and ships equipped with missiles are ready now.

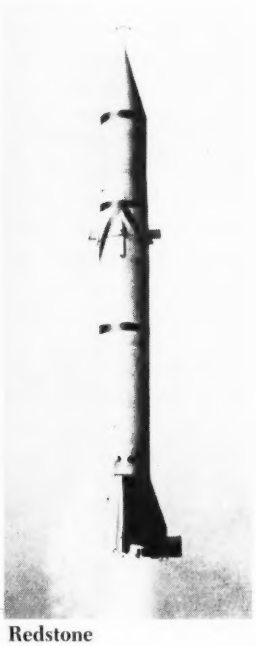
AIR FORCE—In addition to the first public discussion of the **Bull Goose** and **Green Quail** missiles, AF spokesmen noted that a guided version of the **Genie** nuclear warhead air-to-air rocket is on the way; development is well along on the **Hound Dog** air-to-surface missile for the B-52; and its successor, an air-launched ballistic missile with IRBM capability, is also under study. Other projects: A boost-glide vehicle which would be an extension of the X-15 concept; use of existing missiles to orbit recoverable vehicles; and lunar probe vehicles utilizing existing hardware. In this category, it was noted that by using the basic Thor IRBM with other existing rockets as additional stages, a payload could be sent to the moon this year.

Hawk


Jupiter



Nike-Hercules

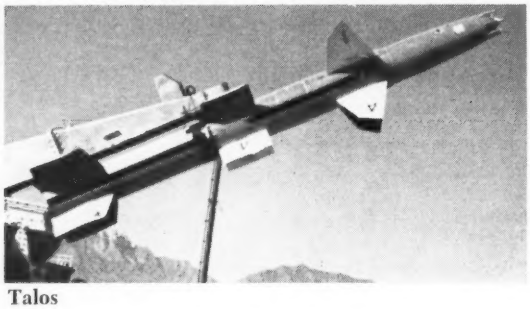

Redstone

ARMY GUIDED MISSILES

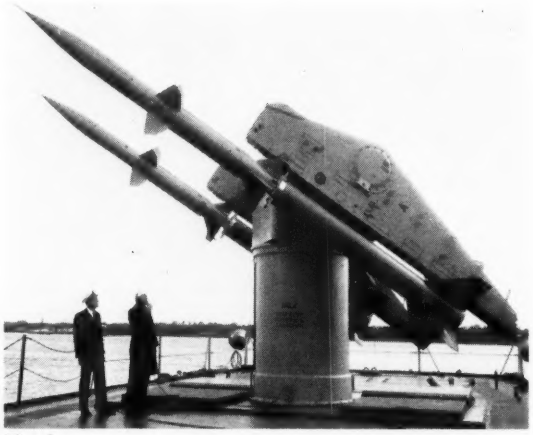
Type	Name	Prime Contractors and Components	Principal Subcontractors and Components
Surface-to-Air	Nike-Ajax	Western Electric Co., New York, N.Y.	Douglas Aircraft Co., Charlotte Ordnance Missile Plant, Charlotte, N.C. Missile
	Nike-Hercules	Western Electric Co., New York, N.Y.	Consolidated Western Steel, Los Angeles, Calif. Launcher
		Douglas Aircraft Co., Charlotte Ordnance Missile Plant, Charlotte, N.C. Missile (exclusive of guidance), launching & assembly area equipment	Goodyear Aircraft Corp., Akron, Ohio. Booster
			Borg-Warner, Ingersoll Div., Kalamazoo, Mich. Booster metal parts
	Nike-Zeus	Western Electric Co., New York, N.Y.	Douglas Aircraft Co., Santa Monica, Calif. Missile, launching & handling equipment
			Grand Central Rocket Co., Redlands, Calif. Propellant
	Hawk	Raytheon Mfg. Co., Missile & Radar Div., Bedford, Mass. System	Aerojet-General Corp., Sacramento, Calif. Rocket motor
			Northrop Aircraft Corp., Hawthorne, Calif. Airframe & launcher
			Picatinny Arsenal, Dover, N.J. Warhead & allied accessories
			Food Machinery & Chemical Corp., Ordnance Div., San Jose, Calif. Loader
	Talos (Land-based)	RCA, Camden, N.J.	McDonnell Aircraft Corp., St. Louis, Mo. Airframe, propulsion
			Allegany Ballistics Lab., Cumberland, Md. Propulsion
			Farnsworth Electronics Co., Ft. Wayne Ind. Guidance
			Bendix Aviation Corp., Bendix Products Div., South Bend, Ind. Propulsion
			Bendix Radio Div., Baltimore, Md. Control system
			Sandia Corp., Albuquerque, N.M. Warhead
			Naval Ordnance Lab., White Oak, Md. Warhead
			New Mexico State College, Socorro, N.M. Warhead
			Naval Ordnance Lab., Corona, Calif. Fuze
			Diamond Ordnance Fuze Lab., Washington, D.C. Fuze
			Melpar, Inc., Washington, D.C. Fuze
			American Machine & Foundry Co., Brooklyn, N.Y. Launching system
Surface-to-Surface	Corporal	Firestone Tire & Rubber Co., Los Angeles, Calif.	Clary Multiplier Co., San Gabriel, Calif. Gyroscope, controls
		Gilfillan Bros., Los Angeles, Calif.	Ryan Aeronautical, Inc., San Diego, Calif. Rocket motor
	Dart	Aerophysics Development Corp., Santa Monica, Calif.	Bulova Research & Development Labs., Flushing, N.Y. Fuze
		Utica-Bend Corp., Utica, Mich.	Whittaker Gyroscope Co., Van Nuys, Calif. Gyroscope
		Grand Central Rocket Co., Redlands, Calif. Rocket motor, propellant manufacture & loading	
	Jupiter	Army Ballistic Missile Agency, Redstone Arsenal, Huntsville, Ala.	Rocketdyne Div. of North American Aviation, Canoga Park, Calif. Rocket motor & associated equipment
		Chrysler Corp. Missile Div., Detroit, Mich. Missile fuselage and assembly	Ford Instrument Div. of Sperry Rand Corp., Long Island City, N.Y. All-inertial guidance package
	Lacrosse	Cornell Aeronautical Laboratory, Buffalo, N.Y. System responsibility	Federal Telecommunications Labs., Nutley, N.J. Computer, distance-measuring equipment & angle tracer
		The Martin Co., Baltimore, Md. R&D co-contractor, system production	Farrand Optical Co., New York, N.Y. Target survey unit
		Thiokol Chemical Corp., Redstone Arsenal Huntsville, Ala. Motor development	
	Redstone	Army Ballistic Missile Agency, Redstone Arsenal, Huntsville, Ala.	Rocketdyne Div. of North American Aviation, Canoga Park, Calif. Rocket motor & associated equipment
		Chrysler Corp. Missile Div., Detroit, Mich.	Ford Instrument Div. of Sperry Rand, Long Island City, N.Y. Guidance package
			Reynolds Metal Co., Louisville, Ky. Missile fuselage
	Sergeant	Jet Propulsion Laboratory, Pasadena, Calif. System	Thiokol Chemical Corp., Redstone Div. Huntsville, Ala. Motor
		Sperry Gyroscope Co., Salt Lake City, Utah All critical R&D components	

NAVY GUIDED MISSILES

Type	Name	Prime Contractors and Components	Principal Subcontractors and Components
Surface-to-Air	Talos (Shipborne)	Bendix Aviation Corp., Bendix Products Div., Mishawaka, Ind.	McDonnell Aircraft Corp., St. Louis, Mo. Airframe, propulsion Allegany Ballistics Lab., Cumberland, Md. Propulsion Farnsworth Electronics Co., Ft. Wayne, Ind. Guidance Bendix Aviation Corp., Bendix Products Div., South Bend, Ind. Propulsion Bendix Radio Div., Baltimore, Md. Control system Sandia Corp., Albuquerque, N.M. Warhead Naval Ordnance Lab., White Oak, Md. Warhead New Mexico State College, Socorro, N.M. Warhead Naval Ordnance Lab., Corona, Calif. Fuze Diamond Ordnance Fuze Lab., Washington, D.C. Fuze American Machine & Foundry Co., Brooklyn, N.Y. Launching system Varian Associates, Palo Alto, Calif. Power tubes
	Tartar	Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md. Convair, Pomona, Calif. Airframe, guidance Allegany Ballistics Lab., Cumberland, Md. Propulsion New Mexico State College, Socorro, N.M. Warhead Bendix Pacific Corp., Santa Monica, Calif. Fuze. Philco Corp., Philadelphia, Pa. Fuze Aerojet-General Corp., Sacramento, Calif. Propulsion Vitro Corp. of America, Silver Spring, Md. Systems engineering Raytheon Mfg. Corp., Wayland, Mass. Radar Ford Instrument Div. of Sperry Rand, Long Island City, N.Y. Computer GE, Pittsfield, Mass. Director Bell Laboratories, Whippany, N.J. Weapon control equipment	
	Terrier	M. W. Kellogg Co., Jersey City, N.J. Booster & sustainer Convair, Pomona, Calif. Allegany Ballistics Lab., Cumberland, Md. Propulsion The Hicks Co., Hyde Park, Mass. Booster & sustainer	Diamond Ordnance Fuze Lab., Washington, D.C. Fuze Philco Corp., Philadelphia, Pa. Fuze Eastman Kodak, Rochester, N.Y. Fuze Elgin National Watch Co., Burbank, Calif. Fuze Bulova Watch Co., New York, N.Y. Fuze Bendix Pacific, N. Hollywood, Calif. Hydraulics & air motor Thompson Products, Cleveland, O. Auxiliary power supply
Air-to-Air	Sidewinder	Philco Corp., Philadelphia, Pa. GE, Utica, N.Y. Norris-Thermador Corp., Los Angeles, Calif. Propulsion metal parts Hunter Douglas, Riverside, Calif. Propulsion metal parts Philco Corp., Philadelphia, Pa. Guidance Eastman Kodak, Rochester, N.Y. Fuze Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. Fuze Elgin National Watch Co., Elgin, Ill. Fuze Baldwin Piano Co., Cincinnati, O. Fuze Houdaille Industries, Buffalo, N.Y. Warhead Naval Powder Factory, Indianhead, Md. Propulsion grain	Electronics Corp. of America, Cambridge, Mass. IR components IR Industries, Needham, Mass. IR components Bausch & Lomb, Rochester, N.Y. Guidance & control American Machine & Foundry Co., Buffalo, N.Y. Guidance

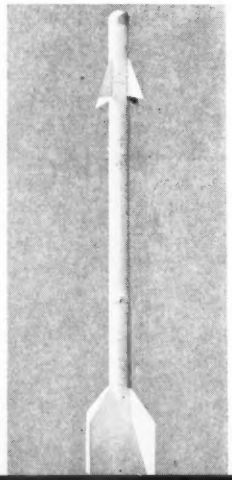


Talos

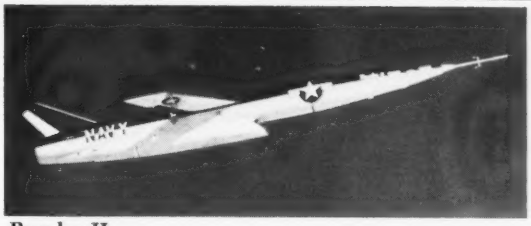


Terrier

Sidewinder



Type	Name	Prime Contractors and Components	Principal Subcontractors and Components
	Sidewinder (continued)	Naval Gun Factor, Washington, D.C. Warhead	
		Naval Mine Depot, Yorktown, Va. Warhead loading	
		Bulova Research Lab., Woodside, N.Y. Fuze	
		Hamilton Watch Co., Lancaster, Pa. Fuze	
		Beatrice Field Tank Co., Beatrice, Neb. Shipping containers	
		Allied Federal Industries, Newark, N.J. Warhead metal parts	
	Sparrow I	Sperry Gyroscope Co., Great Neck, L.I., N.Y. and Bristol, Tenn.	Douglas Aircraft Co., Santa Monica, Calif. Airframe
			Aerojet-General Corp., Azusa, Calif. Propulsion
			Sperry Gyroscope Co., Great Neck, L.I., N.Y. Guidance
			Tranter Mfg. Co., Lansing, Mich. Warhead
			Congoleum-Nairn Co., Kearney, N.J. Warhead
			Bendix Aviation Corp., York, Pa. Fuze
	Sparrow II	Douglas Aircraft Co., Santa Monica, Calif.	Douglas Aircraft Co., Santa Monica, Calif. Airframe
			Aerojet-General Corp., Azusa, Calif. Propulsion
			Bendix Aviation Corp., Burbank, Calif. Guidance
			Naval Ordnance Lab., Corona, Calif. Fuze & warhead
			Bendix Aviation Corp., Detroit, Mich. Fuze
			Elgin National Watch Co., Burbank, Calif. Safety & arming
	Sparrow III	Raytheon Mfg. Co., Bedford, Mass.	Raytheon Mfg. Co., Bedford, Mass. Airframe, guidance, fuze
			Aerojet-General Corp., Azusa, Calif. Propulsion
			Naval Ordnance Lab., White Oak, Md. Warhead
			Rheem Mfg. Co., Downey, Calif. Warhead
			Elgin National Watch Co., Burbank, Calif. Safety & arming
Air-to-Surface	**Corvus**	Temco Aircraft Corp., Dallas, Tex.	Reaction Motors, Inc., Denville, N.J. Propulsion
			Texas Instruments, Inc., Dallas, Tex. Guidance
			W. L. Maxson Corp., New York, N.Y. Guidance
	Bullpup	The Martin Co., Middle River, Md. and Orlando, Fla.	Aerojet-General Corp., Azusa, Calif. Propulsion
			Naval Ordnance Lab., Corona, Calif. Fuze
			Elgin National Watch Co., Elgin, Ill. Fuze
	Petrel	Fairchild Engine & Airplane Corp., Guided Missile Div., Wyandanch, L.I., N.Y.	Fairchild Engine & Airplane Corp., Guided Missile Div., Wyandanch, L.I., N.Y. Airframe, propulsion, guidance & fire control equipment
			Naval Ordnance Lab., White Oak, Md. Fuze
			Lockheed Aircraft Corp., Burbank, Calif. Launcher
			Naval Ordnance Plant, Forest Park, Ill. Warhead
			Belock Corp., New York, N.Y. Fuze
Surface-to-Surface	**Polaris**	Lockheed Missile Systems Div., Sunnyvale, Calif. Missile system	Aerojet-General Corp., Sacramento, Calif. Propulsion subcontractor to Lockheed
		Interstate Electronics Corp., Anaheim, Calif. Instrumentation	MIT, Cambridge, Mass. Associate contractor to Lockheed on guidance development
		Westinghouse Corp., Sunnyvale, Calif. Launcher design	GE, Pittsfield, Mass. Guidance production & fire control subcontractor to Lockheed
			Bureau of Ships, Washington, D.C. Ship design
			Atomic Energy Commission, Los Alamos, N.M. Warhead
	Regulus I	Chance Vought Aircraft, Dallas, Tex.	Chance Vought Aircraft, Dallas, Tex. Airframe, guidance
			Allison Div. of General Motors, Indianapolis, Ind. Propulsion
			Sandia Corp., Albuquerque, N.M. Warhead & fuze
	Regulus II	Chance Vought Aircraft, Dallas, Tex.	Chance Vought Aircraft, Dallas, Tex. Airframe
			GE Aircraft Gas Turbine Div., Cincinnati, O. Propulsion
			A-C Electronics Div. of General Motors, Milwaukee, Wis. Guidance
			Sandia Corp., Albuquerque, N.M. Warhead & fuze
			Texas Instruments, Inc., Dallas, Tex. Computer

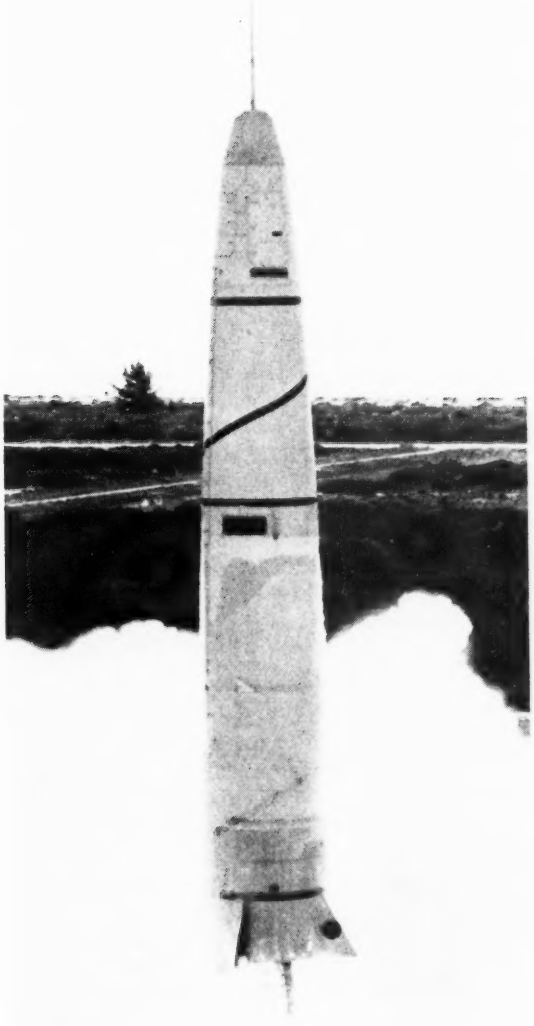


Regulus II

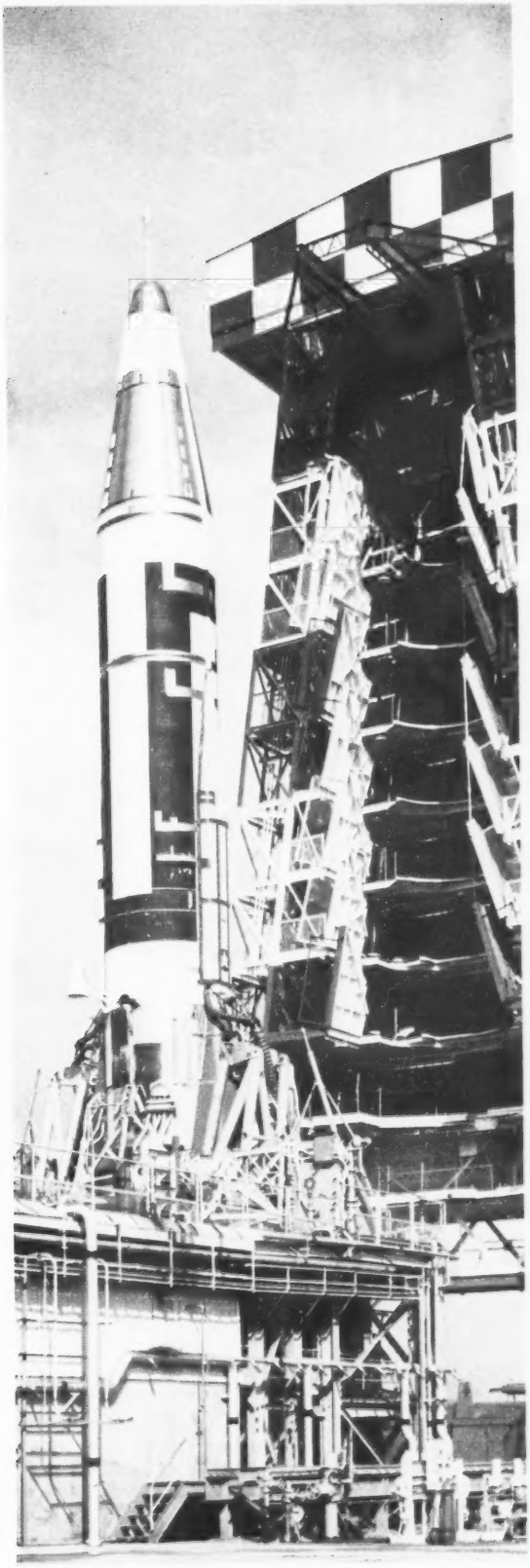
AIR FORCE GUIDED MISSILES

Type	Name	Prime Contractors and Components	Principal Subcontractors and Components
Air-to-Air	Falcon	Hughes Aircraft Co., Culver City, Calif.	Thiokol Chemical Corp., Redstone Arsenal, Huntsville, Ala. Rocket engine
			Willard Storage Battery Co., Cleveland, O. Battery
			Avco Mfg. Corp., Richmond, Ind. Stabilizer, missile container, flipper
			Vectron, Inc., Waltham, Mass. Frequency converter
			General Sintering Corp., Melrose Park, Ill. Fuze, fuze arming
	Bull Goose	Fairchild Engine & Airplane Corp., Aircraft Div., Hagerstown, Md.	American Machine & Foundry Co., Brooklyn, N.Y. Ground support equipment
		Ramo-Wooldridge Corp., Los Angeles, Calif. Associate contractor on electronics	Paul Omohundro Co., Los Angeles, Calif. Airframe components
Air-to-Surface	Rascal	Bell Aircraft Corp., Niagara Falls, N.Y.	RCA, Camden, N.J. Guidance components
			Texas Instruments, Inc., Dallas, Tex. Guidance components
			Arma Div., American Bosch Arma Corp., New York, N.Y. Guidance components
	Green Quail	McDonnell Aircraft Corp., St. Louis, Mo.	GE, Lynn, Mass. Powerplant
			American Machine & Foundry Co., Brooklyn, N.Y. Support equipment
		Boeing Airplane Co., Seattle, Wash. Aircraft modification	Ramo-Wooldridge Corp., Los Angeles, Calif. Electronics
Surface-to-Air	Bomarc	Boeing Airplane Co., Seattle, Wash.	Aerojet-General Corp., Azusa, Calif. Rocket booster
			Marquardt Aircraft Co., Van Nuys, Calif. Ramjet engine
			Westinghouse Electric Corp., Baltimore, Md. Homing radar, flight control equipment
Surface-to-Surface	Matador	The Martin Co., Baltimore, Md.	No major subsystems subcontracted; most components are from subcontractors and vendors
	Mace	The Martin Co., Baltimore, Md.	Goodyear Aircraft Corp., Akron, O. Guidance
			A-C Electronics Div. of General Motors, Milwaukee, Wis. Inertial guidance
	Atlas	Ramo-Wooldridge Corp., Los Angeles, Calif. Systems engineering & technical direction	Convair, San Diego, Calif. Airframe
			GE, Schenectady, N.Y. Nose cone
		Convair, San Diego, Calif.	Rocketdyne Div. of North American Aviation, Canoga Park, Calif. Propulsion
			GE, Syracuse, N.Y. Guidance
			Burroughs Corp., Paoli, Pa. Guidance
			Atomic Energy Commission, Los Alamos, N.M. Warhead
			Sandia Corp., Albuquerque, N.M. Fuze
			American Machine & Foundry Co., Pacoima, Calif. Support equipment & auxiliary power unit
	Snark	Northrop Aircraft, Inc., Hawthorne, Calif.	None
	Thor	Ramo-Wooldridge Corp., Los Angeles, Calif. Systems engineering & technical direction	Douglas Aircraft Co., Santa Monica, Calif. Airframe
			GE, Schenectady, N.Y. Nose cone
		Douglas Aircraft Co., Santa Monica, Calif.	Rocketdyne Div. of North American Aviation, Canoga Park, Calif. Propulsion
			A-C Electronics Div. of General Motors, Milwaukee, Wis. Guidance
			Atomic Energy Commission, Los Alamos, N.M. Warhead design & development
			Sandia Corp., Albuquerque, N.M. Fuze design & development
	Titan	Ramo-Wooldridge Corp., Los Angeles, Calif. Systems engineering & technical direction	The Martin Co., Denver, Colo. Airframe
			Avco Mfg. Corp., Stratford, Conn. Nose cone
		The Martin Co., Denver, Colo.	Bell Telephone Labs., Whippany, N.J. Guidance
			American Bosch Arma Corp., Garden City, L.I., N.Y. Guidance
			Sperry Rand Co., St. Paul, Minn. Guidance
			Aerojet-General Corp., Sacramento, Calif. Propulsion
			Atomic Energy Commission, Los Alamos, N.M. Armament
			Sandia Corp., Albuquerque, N.M. Armament
			Aerojet-General Corp., Sacramento, Calif. Support equipment & auxiliary power unit

Snark



Thor



Atlas

Getting missiles off to a good start

Here's how Army Ordnance bypasses explosive hazards and insures reliable ignition and smooth combustion of rocket engines used in Army missiles

By Paschal E. Redding Jr.

REDSTONE ARSENAL, HUNTSVILLE, ALA.

P. E. Redding Jr. is a staff member of the Research and Development Div. at Redstone Arsenal charged with monitoring and coordination of R&D work on rocket powerplants. A chemical engineer, he specializes in materials and propellants for new rocket engine designs. He came to Redstone late in 1953 and is now a member of the Technical Advisory Panel on Liquid Propellants to the Assistant Secretary of Defense for Research and Development and an adviser on the status of research and development to the Fire-Power Sub-Panel of the Army Scientific Advisory Panel. He is also a member of the Redstone Arsenal's Materials Committee for Rockets and Guided Missiles.

TOP ROCKET engineers agree that the most difficult thing about the operation of a rocket motor is reliable ignition. Many propellant mixtures will not ignite spontaneously and must be energized before they will undergo sustained burning.

The spark plug was first used successfully to ignite the bipropellant combination of alcohol and liquid oxygen. The spark plug was built into the injector where the fuel and oxidizer vapors formed an ignitable mixture. Here it was subjected to the high temperature and erosive action of the hot combustion gases; the electrodes deteriorated rapidly; and the spark plugs thus had to be replaced frequently.

Can Be Ignited With Spark Plugs

Propellant mixtures that have a high reaction rate, such as liquid oxygen and alcohol, are readily ignited with a normal spark plug by controlling the flow of liquid oxygen and alcohol to a few pounds per second. However, an ignition delay of a fraction of a second longer than normal can cause a rough start or a pressure peak large quantity of unburned propellant in this combustion chamber, And too long an ignition delay can result in the accumulation of a large quantity of unburned propellant in this combustion chamber, resulting in a violent and sometimes disastrous explosion, which may result in destruction of the missile and valuable test equipment, and even loss of human lives.

To bypass this explosive hazard and insure reliable ignition and smooth combustion of the JP-4 fuel and red fuming nitric acid oxidizer in the rocket motor of one Army guided missile, the Ordnance Corps employs auxiliary fluid type ignition. This method involves the simultaneous introduction of a "starting" fluid into the motor chamber with the red fuming nitric acid oxidizer. These starting fluids are "hypergolic fuels," i.e., they react spontaneously with the oxidizer immediately after being injected into the main rocket combustion chamber.

Such fuel combinations are readily adaptable to the ignition of the primary rocket propellants. Once the temperature of part of the primary oxidizer-fuel mixture is raised to the ignition point, the propellant flow is regulated so that the flame is spread throughout the rest of the regular fuel mixture.

Plasma-type aluminum bottle is used to introduce hypergolic starting mixture into a Nike-Ajax. Igniter fuel is added in last operation performed by launching crew before missile is fired.

The auxiliary field ignition procedure followed by Army Guided Missile Troops for starting rocket motors with hypergolic fuels is as follows:

First, the igniter fuel is fed directly into the regular fuel line by gravitation from a metal bottle similar in design to a blood plasma bottle. Then, deposited in a section of the regular fuel line between the fuel tank and the combustion chamber, the ignition mixture is separated from the JP-4 fuel by a burst diaphragm.

To start the motor, the igniter and oxidizer line diaphragms are burst with regulated air pressure. The igniter fluid is forced into the motor simultaneously with the nitric acid from the oxidizer tank, resulting in a hypergolic reaction which ignites the fuel-acid mixture. The JP-4 sustainer fuel immediately follows the igniter through the same fuel line into the combustion chamber. The continuous flow of JP-4 and nitric acid to the motor is properly proportioned by propellant valves to obtain sustained, smooth combustion.

The first starting fluid used by Army Ordnance for the ignition of the rocket motors was a mixture of 50 per cent furfuryl alcohol and 50 per cent aniline by weight. Relatively small quantities of this hypergolic mixture are required to initiate combustion, and each starting charge can be conveniently stored in a one-quart aluminum container. Aniline itself was one of the earliest rocket fuels considered for liquid bipropellant systems. Its use as a rocket propellant was prompted by its favorable characteristics, such as lack of detonability from shock, good coolant properties and spontaneous ignition with red fuming nitric acid, nitrogen tetroxide and white fuming nitric acid. The vapor pressure of aniline is low and therefore presents no storage problem due to excessive pressure build-up.

Certain other factors, however, argue against the extensive use of aniline. Among these are its toxicity, high freezing point and limited availability. Its high freezing point of 20 F would restrict its field use, so it is necessary to use an additive which will not detract from its hypergolic qualities, but will at the same time have physical characteristics close to that of aniline itself. Furfuryl alcohol is particularly suited for this (CONTINUED ON PAGE 72)

Launching crew begins feeding hypergolic fuel which acts both as igniter mixture and sustainer fuel into Corporal missile.

Flight to the moon

The complete story, in pictures, of Donald Farrell's week-long simulated space voyage at the USAF School of Aviation Medicine

LAST LOOK: Farrell takes a last look outside before cabin was sealed. Movie cameras are overhead and at right; portable TV camera at left.

WHILE the experiment at the Air Force School of Aviation Medicine, Randolph AFB, Tex., in mid-February, in which 23-year-old Airman Donald G. Farrell successfully completed a simulated seven-day flight to the moon and back, did not answer all the questions that will confront the first space man, it did provide experimental proof that a space cabin can be designed to allow a human being to survive almost indefinitely in space and function as normally as he would in an earthly environment.

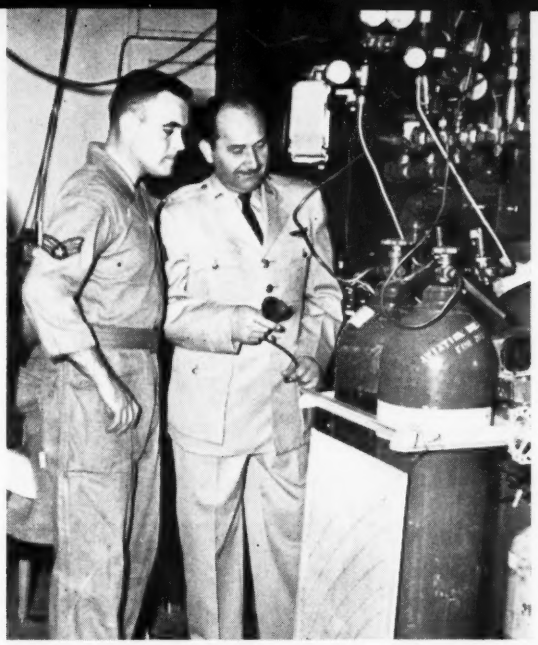
The cabin—6 ft long, 3 ft wide, and 5 ft high—was designed to provide data on respiratory requirements for keeping a man alive and carrying out routine duties in space; on his physiological reactions in an atmosphere differing from that found on earth; on his psychological reactions to such a flight; and on his adaptation to an abnormal day-night cycle.

To obtain this data, atmospheric pressure in the cabin was lowered to half that of normal pressure at sea level, or about 8 psi, and an atmosphere made up of 40 per cent oxygen and 60 per cent nitrogen, compared with the normal 20-80 composition, was used to provide Farrell with a normal oxygen supply. He was also placed on an artificial diurnal cycle—a 14-hour day made up of two work periods of four hours each, four and one-half hours of sleep and three half-hour periods for meals and personal hygiene.

Proves Man Can Adjust

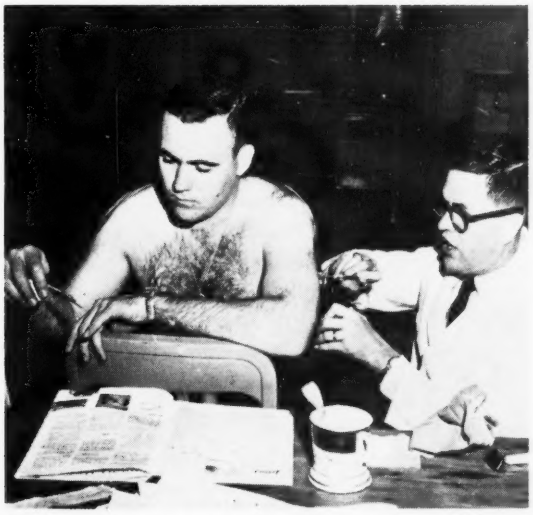
While detailed analysis of the data compiled during the experiment will take months, the fact that Farrell came through the trip without apparent ill effects, either from the psychological or physiological standpoint, is of primary importance, since it clearly indicates that man can adjust to an abnormal atmosphere, as well as to an unusual day-night cycle.

Although the experiment did not concern itself with such matters as cosmic ray and ultraviolet radiation or the enormous accelerations which will be met in space vehicles, it did supply strong evidence of man's ability to venture out into space.



PRE-FLIGHT BRIEFING: Airman Donald G. Farrell (left) gets pre-ascension briefing from Lt. Col. G. R. Steinkamp, Chief of the School's Space Medicine Dept.

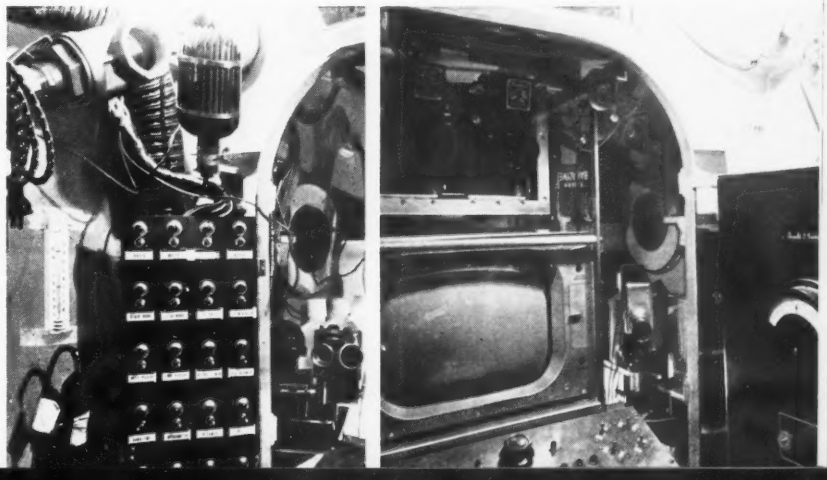
IT WORKS THIS WAY: Fenton Duepner (left), electronics engineer at the School, goes over cabin instrumentation with Farrell as part of pre-flight briefing.



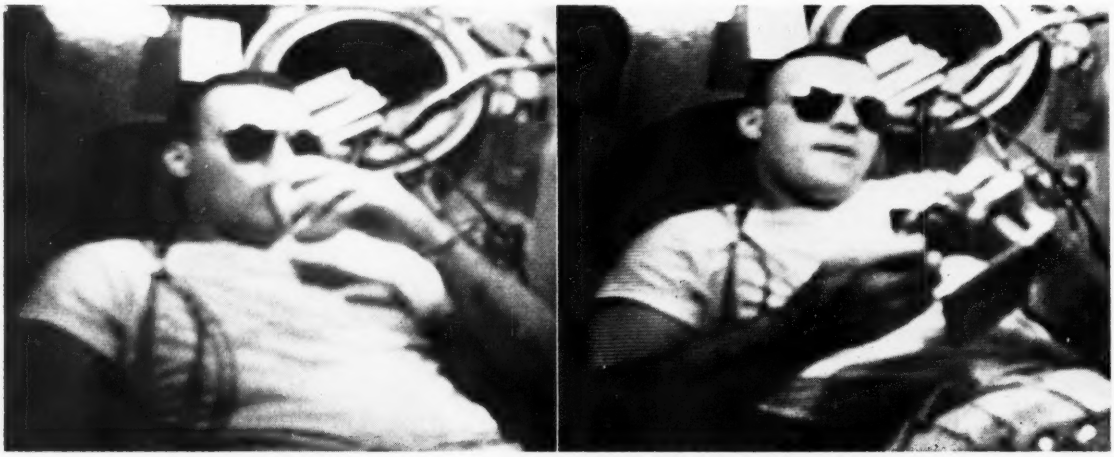
HOOKED UP: Capt. Julian E. Ward (right), flight surgeon on the project, attaches electrodes to Farrell shortly before simulated flight got under way.

DEPARTURE: Farrell climbs into experimental space cabin at AF School of Aviation Medicine as take-off time for simulated flight to moon approaches.

SPACE CABIN CONTROLS: This is the view Farrell had during his week-long flight. Panel in photo at right was only contact with outside world; allowed him to deodorize cabin, adjust humidity, tune TV set and play music. Panel below TV set in photo at far right contains simulated space ship controls.



CHECK-UP: Dr. Willard R. Hawkins records observations of Farrell on TV monitor as "space man" passed 30th hour of simulated flight.



IN FLIGHT: Farrell appears completely relaxed as he sips coffee (left), winds clock which told him whether it was night or day (right), as he approached 60th hour of flight. Photos were taken from TV monitor screen.

HOME AT LAST: Looking little the worse for wear, Farrell is assisted from space chamber by Capt. Ward after completion of mission.

SPACE MAN'S STEAK: Farrell eyes a healthy-sized steak at Randolph AFB hospital, where he was taken for 72-hour observation after completing the test.

Human crews for space ships

An aviation psychologist notes that, while the isolation involved in interplanetary flight will produce extraordinary stresses, man has often conquered similar situations in the past

By J. E. Pournelle

AVIATION PSYCHOLOGIST,
BOEING AIRPLANE CO., SEATTLE, WASH.

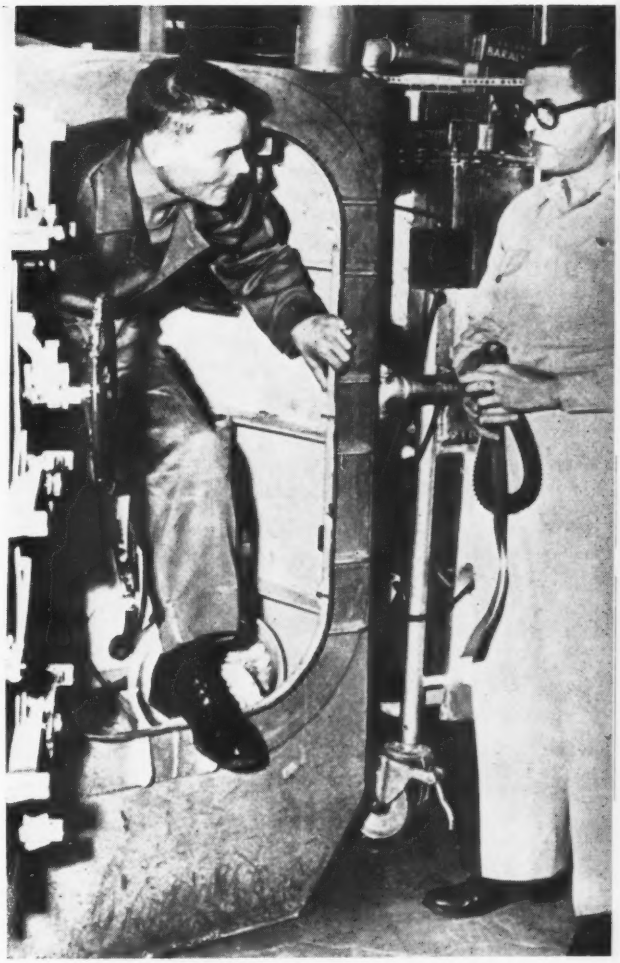
THERE HAS been, in recent months, much speculation about the problem of boredom and insanity among human operators of interplanetary rockets, and it almost inevitably occurs to those interested in the problem that the simplest solution is to eliminate the human crew altogether.

However, there will presumably be some necessity for humans to arrive at planetary destinations, and proposals have been made that we send humans as dormant cargo, nursed by electronic circuitry in the ships and revived on arrival.

Human Cargo Solution Is Unlikely

Unfortunately, reliability and technical problems make the human cargo solution unlikely, at least for some time after the foreseeable development of interplanetary rockets. In addition, it is doubtful that we would be able to find persons interested in entrusting their lives to electronic gadgetry for several months. Although the ship will have to sustain the lives even of conscious crew members, there is no reason why its duties should be overly strained.

These startling proposals, and others like them, are offered in answer to a problem which may be largely imaginary. While it is true that unusual stresses will result from long, isolated rocket flights, and that boredom and insanity will be dangers, the situation is not unparalled in human experience, and there is no reason to presume that normal, fully conscious human beings will not be able to make a six- to eight-month journey through interplanetary space.



Airman 2.C. F. W. Childress returns from "flight" in experimental space cabin at School of Aviation Medicine, Randolph AFB, Tex., used to test reactions of human beings to long periods of isolation.

Without analyzing in detail the presumed lack of duties for human operators and the proposed technical skills which would enable us to send rockets some millions of miles without course corrections, let us take a look at what human operators *could* do on such a trip, and try to determine whether fully conscious human beings have not encountered similar, or even worse, situations in the past, and come through them successfully.

First, there is no questioning the fact that intelligent human maintenance and routine servicing would improve chances for a successful flight. In-flight maintenance is use- (CONTINUED ON PAGE 81)

Laboratory for space research

Combination of high-vacuum chamber and pressure suit affords means of investigating effects of a space-like environment right here on earth

By Herbert Reich

TECHNICAL COORDINATOR, RESEARCH LABORATORIES
LITTON INDUSTRIES, BEVERLY HILLS, CALIF.

WITH THE world's attention focused on space and space travel, more and more interest is being shown in the problems which will be encountered in an airless environment. Efforts in this area have centered on devising a means of placing man in an airless environment where he can directly experiment with, observe and experience the new sensations of such an environment with a minimum of artificial barriers consistent with his continued survival and comfort.

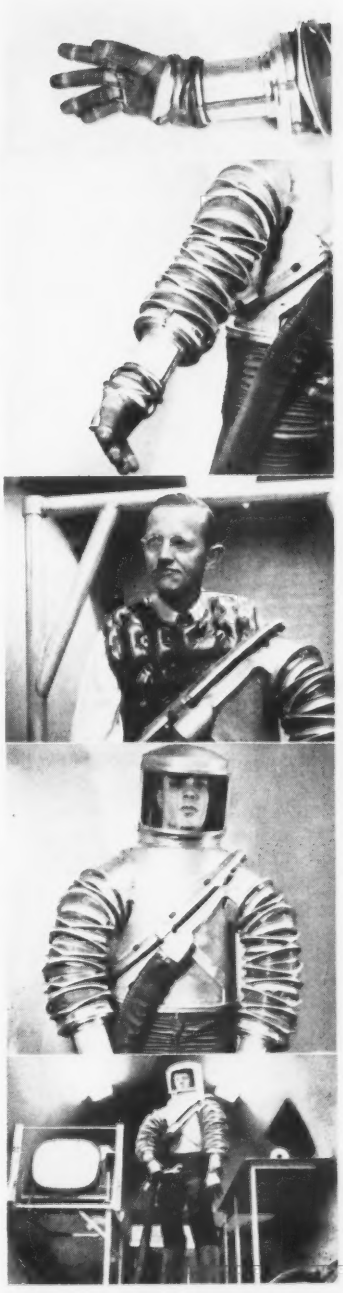
Aside from the obvious physiological and psychological problems associated with survival in outer space, many mechanical phenomena of an air-soaked environment appear to undergo quixotic changes in their extrapolation to a vacuum environment. A significant increase in mechanical friction, degradation of lubricants and plastics by gas evolution, and increased affinity of metals for metals are some of these changes.

Suit Lets Scientist Live in "Outer Space"

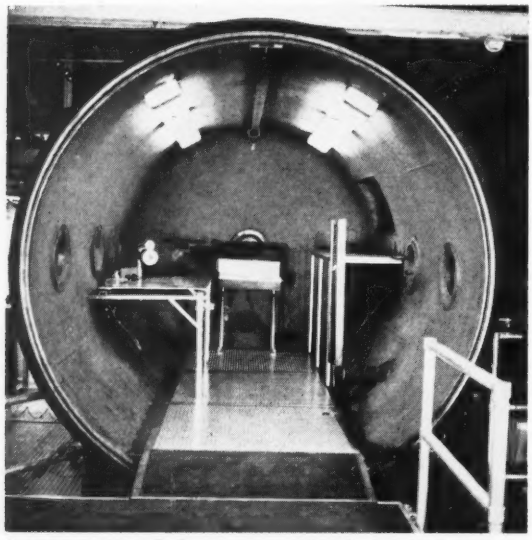
To provide a means for gaining information on the effects of a space-like environment, Litton Industries, in cooperation with the Air Force Office of Scientific Research, has developed the Space Research Laboratory. This laboratory is being used for special research and evaluation studies in an atmosphere corresponding to altitudes in excess of 100 miles and as an environmental tool for subjecting equipment destined for space travel to simulated space conditions.

The laboratory provides an evacuated space in which both the test article and the researcher can be placed, and thus differs from the ordinary vacuum chamber, which isolates the equipment from the researcher. The new concept was made possible by the development of a protective suit which encloses the scientist in a livable atmosphere without impairing his ability to observe in detail the progress of experiments or to make adjustments on the test article. In addition, attainment of extremely high vacuum in a large manned

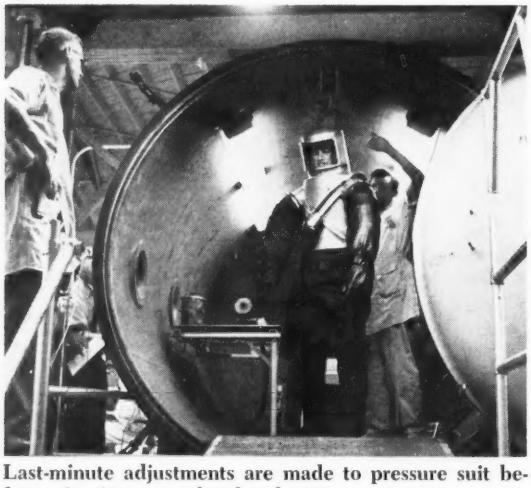
High-vacuum chamber and protective suit, two main elements in Litton's Space Research Laboratory.



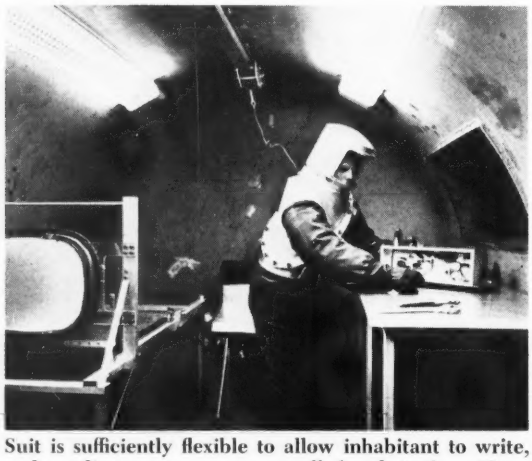
Details of the full-pressure suit, which provides a protective, livable environment for the wearer in the chamber.



Interior view of the vacuum chamber, which can be evacuated to 10^{-6} mm of Hg.



Last-minute adjustments are made to pressure suit before scientist enters the chamber.



Suit is sufficiently flexible to allow inhabitant to write, make adjustments or use small hand tools. Here, researcher adjusts electronic equipment.

chamber required the development of many new vacuum techniques.

The laboratory facility, shown on page 36, consists of a horizontally placed cylindrical vacuum vessel, the associated vacuum pumping equipment and the inhabitant's protective suit and suit support systems.

The chamber itself is 8 ft in diam, 15 ft long and constructed of $^1/_2$-in. hot-rolled steel, with the major joints machined-welded. The ends are sealed by elliptical end bells, one of which is used as a sliding door for access to the chamber. Sealing is accomplished by means of a neoprene gasket between the door and cylinder end.

There are 10 general purpose ports, interchangeable for viewing, instrumentation leads or other connections. The chamber includes an aluminum floor plate, removable work benches, fluorescent lights and an overhead monorail for load handling. A rectangular manifold flange through the wall of the chamber connects to pumping equipment. An emergency air supply system is permanently connected to a flange on the bottom surface of the chamber.

Dual Pumping System

Pumping equipment consists of a dual system connected in parallel—the mechanical or roughing system and the oil diffusion or high vacuum pumping chain. The roughing pump is used to evacuate the chamber from atmospheric pressure to approximately 500 microns ($^1/_2$ mm of Hg), at which the high vacuum pumping chain takes over to bring the chamber down to its ultimate capability of 10^{-6} mm of Hg.

The full-pressure suit, details of which are shown on page 37, provides the protective, livable environment essential to the well-being of the inhabitant. The extremely low pressure within the vacuum chamber necessitates (1) a continuous supply of oxygen for breathing; (2) continuous removal of body heat, moisture and carbon dioxide; and (3) continuous maintenance of proper internal and external body pressure equilibrium.

The suit is connected through an umbilical cord to an external breathing and ventilating system. Oxygen for breathing must be made available in the proper quantity and at the proper temperature and pressure. Adequate provision for discharging the carbon dioxide formed as the inhabitant exhales is also essential.

With mild exertion, the suit wearer produces body heat at the rate of approximately 1200 Btu/hr. Provisions for the removal of this heat energy must be included or the wearer will become extremely uncomfortable and over- (CONTINUED ON PAGE 78)

From drones to space flight

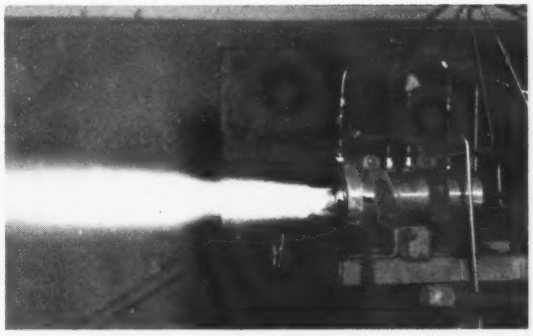
That was the range of ARS technical papers presented at the ASME-ARS Joint Aviation Conference in Dallas last month

THE AMERICAN ROCKET SOCIETY joined the American Society of Mechanical Engineers in sponsoring the Joint Aviation Conference held last month at the Statler-Hilton Hotel in Dallas, Tex. ARS technical sessions at the conference covered solid rockets, guided-missile instrumentation, new high-temperature ceramics and plastics, drones, nuclear propulsion, and, perhaps for diversion, the challenges of lunar colonization.

Study for Ballistic Rockets

In the solid rocket session, J. L. Gallagher and T. E. Phillips of Convair-Fort Worth gave a workmanlike rundown on a design analysis expressing the performance of a solid propellant ballistic missile in terms of its geometry. This form of analysis is not uncommon for small solid propellant rockets, and has doubtless recently been in demand for large complicated solid missiles.

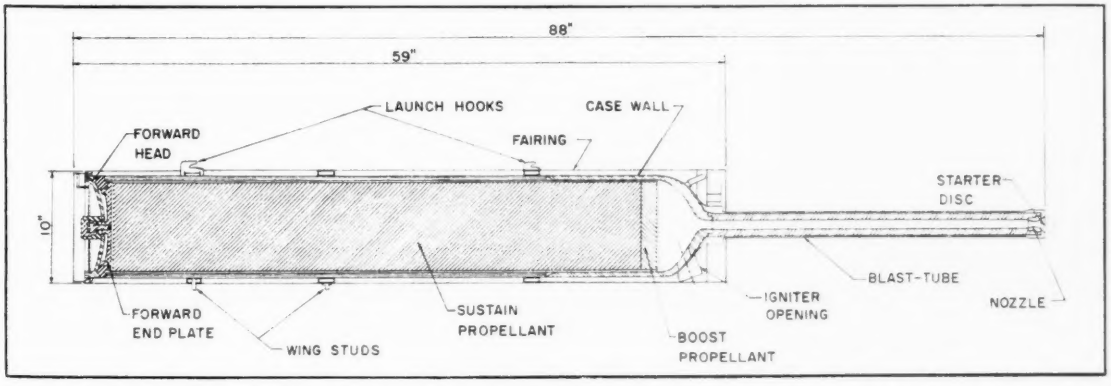
The authors' analysis allows a systematic appraisal of the interrelated problems of weight, acceleration and staging for a ballistic missile. They conclude by observing that "engine weight ratio for a single-stage missile is much lower than that [for] a two-stage missile . . . . However, at a low burnout acceleration limit, launch weight of a two-stage missile will be lower than that of a single-stage missile."



Test model of Reaction Motors liquid bipropellant motor during static firing. Flight version of motor can operate for more than 4 hours without major overhaul.

The authors show their method and results graphically and point out that this method of analysis can be programmed for high-speed computers.

A companion paper by G. E. Miles, Rocket Fuels Div., Phillips Petroleum Co., McGregor, Tex., compares single-chamber dual-thrust and separate booster-sustainer solid propellant motors. He concludes that, although the two systems give comparable over-all specific impulse, the single-chamber dual-thrust motor, operating at two pressure levels, is preferable at thrust (CONTINUED ON PAGE 68)



Longitudinal section of Astrodyne solid propellant motor for Teal drone. Motor burns for 8 minutes in boost and sustain phases.

ASTRONAUTICS Report—Part Two

AFCRC: Test tube for tomorrow

Anti-ICBM radars, meteoritic communication, atom-size memory units—these are but a few of the projects under development by Cambridge Research Center's Electronics Directorate for Air Force of the future

By Michael L. Yaffee

AS NOTED in the first part of this survey, the Air Force Cambridge Research Center consists basically of two independent directorates—the Geophysical Research Directorate and the Electronics Research Directorate.

Last month, the structure, organization, function and projects of GRD were described in detail. Now let's turn our attention to the other half of the story about this major Air Force R&D center.

The Electronics Research Directorate is one of three AF electronic research and development centers. The others are Wright ADC and Rome ADC. The AF Office of Scientific Research, of course, is a fourth source of electronic research and development for the Air Force, but OSR is largely a contracting agency and is concerned largely with more basic programs. Rome and Wright are at the other end of the R&D spectrum—in the operational development area, just a step or two removed from actual production. ERD is somewhere in the middle, overlapping OSR at one end, and Rome and Wright at the other.

Scientist checks growth of silicon crystal in induction furnace. Single crystal will supply enough silicon for thousands of experimental transistors.

Electronic Research Directorate

ERD is a research and technical development directorate. It is not concerned with specific problems and time limits; it is more interested in the development of new concepts. In one of its early assignments, the group tackled the problem of air defense, developed a number of new concepts that were later incorporated into the SAGE system. Half of Lincoln Laboratory's original group of scientists, in fact, came from ERD. Today, the two units have no projects in common other than occasional bull sessions.

For functional purposes ERD is divided into 12 sections. At the top of the table of organization are the director, deputy director and assistant director—respectively, Lowell G. Hollingsworth, Barrett Robert and Lt. Col. Coke Brown. Like his GRD counterpart, Dr. Hollingsworth is directly responsible to the commander of AFCRC and is a member of the AFCRC steering committee.

Three of the 12 ERD sections are staff groups. These are the Programs and Requirements, Engineering and Resources Management Branches. The first formulates and reviews programs to meet AF needs, and determines and apportions resources required by such

programs. The second helps design and engineer test equipment. The third is basically a bookkeeper and administrative unit.

Another section, the Systems Analysis Office, is neither a staff group nor a research laboratory. Rather, its purpose is to bring a fresh, unbiased eye to bear on all AF electronic support systems under development. This group goes over systems such as TAC, BADGE and SAGE with a view to approaching obsolescence, and checks proposals for new systems against specific AF needs.

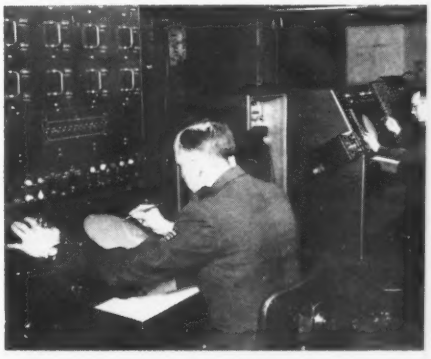
Computer Laboratory

A double-duty outfit, the Computer Laboratory supplies other sections of the directorate with computational services and carries out research aimed at improving analog and digital devices and techniques.

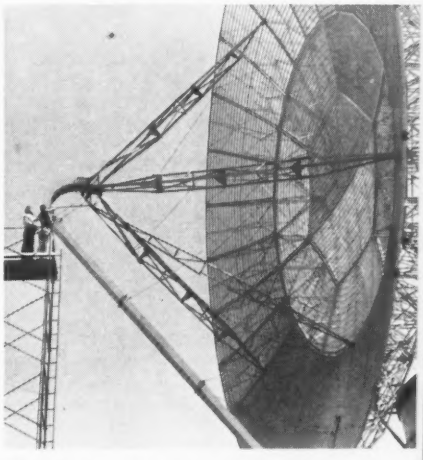
During the past decade, data processing equipment has assumed a central role in AF electronics research. Its importance approaches that of radar and communications, particularly in regard to missile guidance, fire control systems and the various aircraft control systems.

It is the job of the Computer Lab to improve data processing equipment by improving computer memories, increasing operational speeds and by designing more sophistication into smaller packages. For example, the lab is now working on the possible use of electro-

Electron tube filament burns in a vacuum chamber under watchful eye of ERD scientist.

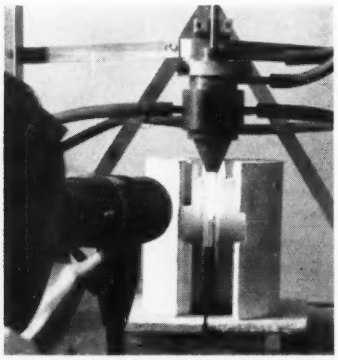


AF operators man consoles of Tactical Air Control System, an experimental ERD system designed to direct and control tactical aircraft operating near a battlefront.

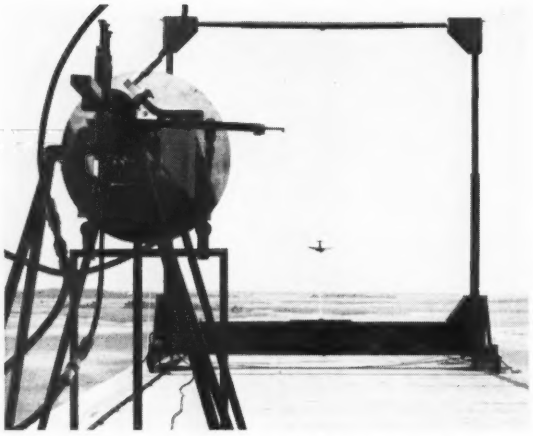


Sixty-foot scatter communications antenna is set atop revolving roof of test building at AFCRCs Ipswich (Mass.) Antenna Test Station.

Time-sequence photo of sunrise is part of ERD's refractive index studies to determine atmospheric influence on radar signals, an important factor in missile tracking.



Scientist studies growth of special sapphire and ferrite crystals in verneuil furnace. These crystals are then tested for possible use in high temperature electronic systems.



Test platform at Ipswich is designed to make radar cross-section measurements using wave lengths scaled down in direct proportion to size of model aircraft or missile used.

luminescent storage in place of the more conventional and much larger magnetic storage. This would involve the storage of data by displacement of an electron from one energy level to another.

Antenna Laboratory

The softest part of a tough-skinned missile or aircraft is often its nose. Where antennas demand a dielectric nose cone, engineers use rubber or plastic. Yet this is the part that must take the brunt of aerodynamic heating, rain erosion and the like.

One series of experiments sponsored by ARDC is aimed at the development of ceramic nose cones that will retain all the dielectric properties of rubber or plastic. AFCRC's Antenna Laboratory is taking a different approach. The answer, according to this group, is flush mounting, by means of which the antenna system becomes a basic part of the vehicle's outer skin.

Airborne antennas, however, represent only half of the work of this section. The other half consists of research and development on ground antennas and associated equipment. One such project is a three-dimensional radar system (height, range, azimuth) which ERD scientists believe will prove to be the first practical 3-D system.

Another important mission of this laboratory is radar cross-section measurements, an integral part of any program designed to come up with an effective anti-missile or antiaircraft radar. Using scale models and scaled-down radar signal wave lengths, the group determines what pattern a particular missile will make on a particular radar system.

Propagation Laboratory

The goal of the Propagation Laboratory is to learn more about electromagnetic propagation and apply new knowledge directly to AF requirements. At present, the lab's major program is devoted to the study of scatter (beyond-the-horizon) propagation. Sizable programs, involving a score of special test sites, are under way to exploit each of the three major scatter techniques—meteoric, ionospheric and tropospheric.

In the past year, the group has plunged deeply into the study of meteoric scatter propagation, including reflection of signals off the ionized trail of a meteor. Such signals are almost impossible to jam or intercept. They can be sent over long distances at frequent intervals because there are about six usable meteors every minute. Meteor trails, of course, last only one or two seconds, so messages are prerecorded and sent at a speeded-up rate.

(CONTINUED ON PAGE 58)

NOTABLE ACHIEVEMENTS AT JPL . . .

THE FIRST AMERICAN SATELLITE

With the launching of the "Explorer," in joint co-operation with the Army Ballistic Missile Agency, the Caltech Jet Propulsion Laboratory fulfills one of its prime functions as a pioneer of the future.

The Army's request for JPL to join in the effort to put an American satellite in orbit was the type of appeal most likely to arouse the enthusiasm of the Laboratory personnel — nearly 2,000 of them.

Challenged by this exceptional opportunity, JPL personnel designed and fabricated the final three stages of the Jupiter "C" missile and, in addition, designed and developed the satellite itself in 80 days.

The close co-operation and co-ordination of effort with the ABMA and the U. S. National Committee for the IGY, make JPL proud to have been a close partner with the U. S. Army in developing and launching the first American satellite.

Now, JPL, maintaining its established policy of scientific research, continues to assist in tracking, receiving, correlating and evaluating data from the "Explorer" as one of its many contributions toward solving the problems of the future.

CAREER OPPORTUNITIES NOW OPEN IN THESE FIELDS

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missile market

Financial news of the rocket and guided missile industry

BY ROBERT H. KENMORE

FEBRUARY price movements were negligible for both the general list and missile industry securities. The lack of any important news, coupled with the prevailing feeling of caution, resulted in the absence of a necessary incentive for the establishment of a trend. Professional Street opinion is still sharply divided on the question of the duration and severity of the current recession. There is little doubt that first quarter earnings will be shocking, and that the market is likely to react rather badly when they appear in print. But whether this trend will continue to the six-months or nine-months statements—in other words, timing of the expected upturn—is uncertain.

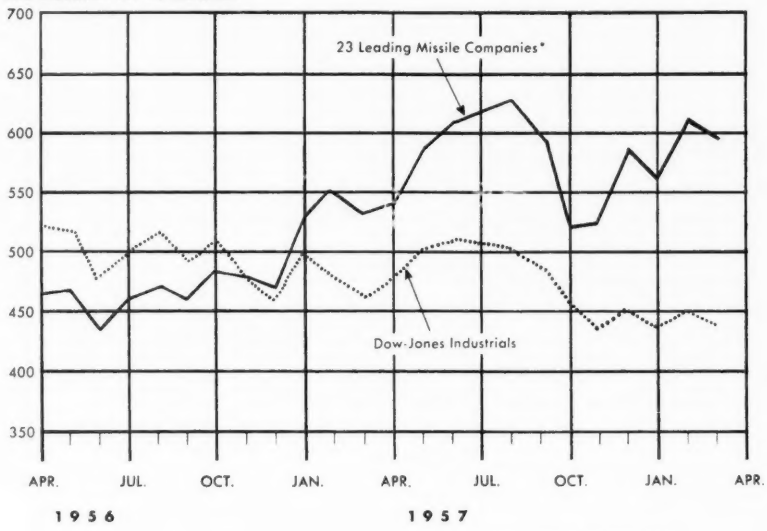
This column feels that because of the time lag between indications of results and the actual release of the news, figures will continue to look pretty horrible for a longer period than people are now expecting.

In a $434 billion economy, trends cannot change overnight. The major, over-all trend is strictly inflationary: Deficit budgets, "pump-priming," Democratic strength and the Washington feeling of keeping everyone healthy and happy "at all costs" during our race for space with Russia makes this inevitable. In the interim, however, some industries are going to take hard knocks, and the long-term investor, who *will* profit from the long-term trend, will have to be gifted with unusual fortitude to avoid selling.

It has already been said in this column that the missile makers paradoxically represent one of the most defensive industries for current investments. This is worth repeating because of the general uncertainty now prevailing about all investments. Obviously the first beneficiaries of the governmentally induced inflation will be the major contractors essential to the nation's security. In this connection it might be interesting to review the latest list of the Top Ten:

	(In Millions of Dollars)
1—General Dynamics	$2,359
2—United Aircraft	1,979
3—General Electric	1,928
4—Boeing	1,924
5—North American Aviation	1,841
6—A.T.&T.	1,339
7—Lockheed	1,193
8—Hughes Aircraft	867
9—Douglas Aircraft	842
10—McDonnell Aircraft	816

THE MARKET AT A GLANCE



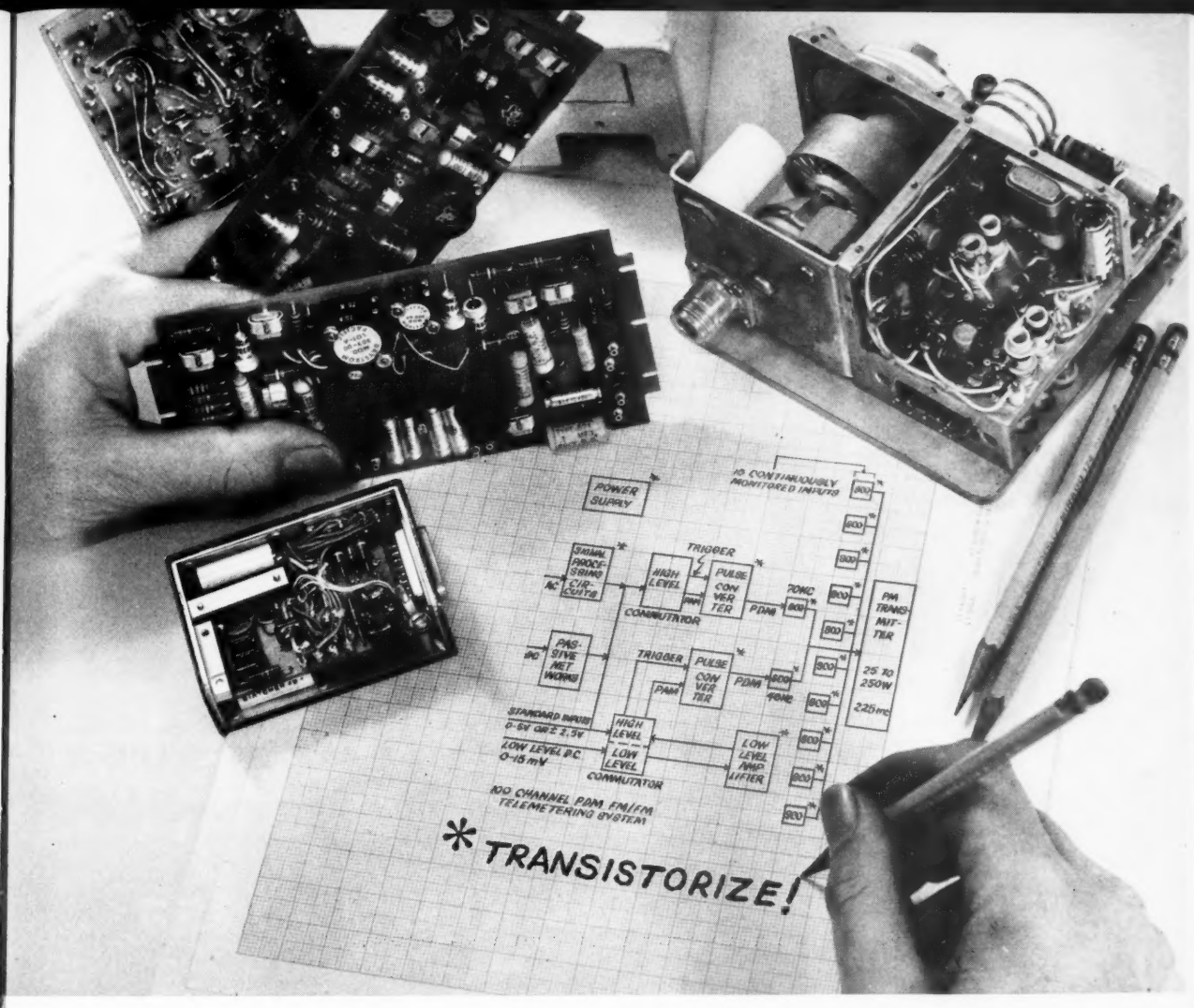
*Index compiled June, 1955

	March 1958	February 1958	% Change	March 1957	% Change
Dow-Jones Industrials	440	450	−2.2	465	− 5.4
Missile Index	593	609	−2.6	534	+11.0

Two further numerical statistics have recently been released which the investor will find interesting to follow on a regular basis. The first is the *Short Interest* figures for the New York Stock Exchange. These figures are watched very closely by the Street although they can be interpreted in two, at-first-glance conflicting, ways. Released on the 15th of every month, the February 15th figure of almost 4 million shares is the highest since February 1932 and is up 25 per cent from the previous month. Although these shares still represent less than 0.1 per cent of the total shares listed on the Big Board, the increase reflects a continuing weakening of the professional investor's confidence in the future of

(CONTINUED ON PAGE 82)

Company	Short Interest 2-14-58	Short Interest 1-15-58	Shares Listed
Boeing Airplane	15,411	21,092	6,953,583
Chance Vought Aircraft	7,938	6,471	1,088,490
Douglas Aircraft	5,249	4,769	3,705,690
General Dynamics	32,784	37,854	9,350,095
General Precision Equip.	6,491	2,238	1,125,725
General Tire & Rubber	24,286	26,476	4,688,376
Litton Industries	8,244	8,198	1,678,980
Lockheed Aircraft	20,400	17,386	2,955,361
The Martin Co.	8,239	9,266	2,922,784
North Amer. Aviation	23,863	21,208	8,015,077
Northrop Aircraft	38,132	45,607	1,570,844
Raytheon Mfg. Co.	9,905	8,008	2,832,180
Sperry Rand Corp.	7,451	5,082	28,279,311
Thompson Products	6,020	10,670	2,758,194



NOW... get more data on Strays and Long Shots

with TI transistorized PDM/FM/FM telemetering systems

Out-of-sight missiles, particularly those off course or in the far reaches of terminal flight, can now send back signals loud and clear — providing data previously blocked by attenuation and noise. This promise can be made because TI-developed transistorized telemetering can now transmit 200 W *and more* without exceeding the space and weight previously required by most 50-W systems. Not "frozen" to old production designs, rugged TI systems and components will *always* represent the practical state of the art. This is the TI policy which resulted in the 200-W *single package* transmitter shown above.

Your requirements in telemetering systems or components can normally be met by existing TI equipment, but your most unique developmental problems are equally welcome. And fast, flexible production facilities will deliver *on time*.

* TI Pulse Duration Modulation telemetering equipment shown, clockwise from lower left: Sub-Carrier Oscillator; Phase Discriminator; Low-Level Amplifier; Keyer; Single-Package 200-W Transmitter.

WRITE TODAY for more information on TI telemetering equipments.

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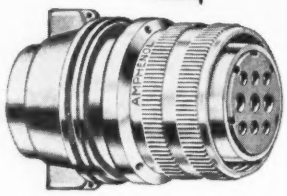
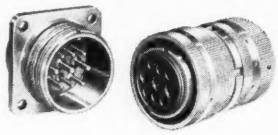


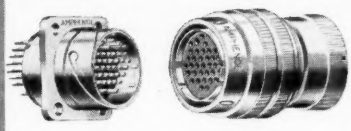
Smallest environmentally resistant MIL-C-5015C MS "E" connectors.

Real E



High temperature (400°F.) "E"-type connectors. Poke Home* contacts.

MINNI E



Miniature MS "E"-type connectors. A complete family of miniatures.

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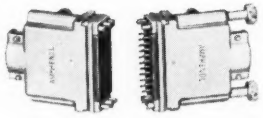
field serviceable

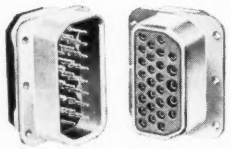
Subminax RF connectors for RG-196/U. Field serviceable, new cable clamp.

93 SERIES



Versatile line of Rack & Panel connectors with Poke Home* contacts.

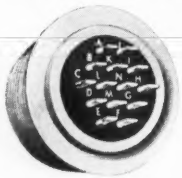
94 SERIES



Polarized-shell Rack & Panels with Poke Home* contacts. Complete line.

*Crimp-type contacts that are wired outside the connector and Poked Home for assembly

Identoseals



Hermetic Seal MS-type receptacles with contact identification on the insert.

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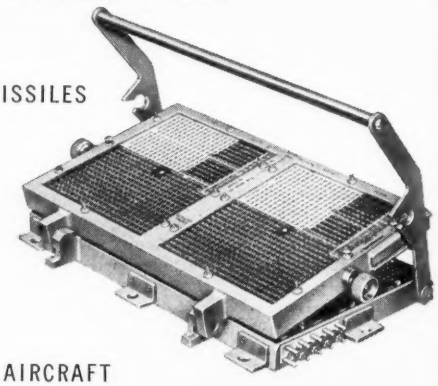

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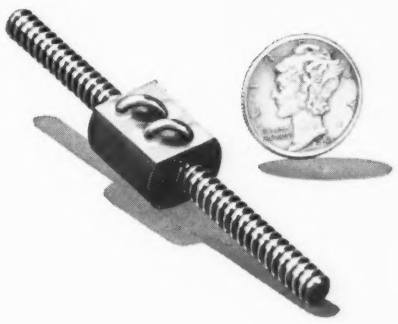
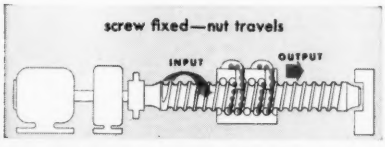
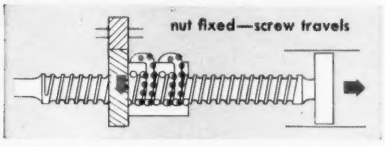
BALL CIRCLE DIAMETER: 3/16 inch.



WORLD'S SMALLEST ball/bearing SCREW SOLVES CRITICAL MINIATURE POSITIONING/CONTROL PROBLEMS



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.



SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.

An unprecedented achievement in minimum size and weight—maximum efficiency, dependability and service life for ultra-precise controls.

It's another first from Saginaw—and the possibilities it opens up for improved electrical and electronic controls are limited only by your imagination! Radar tuners, missile and rocket guidance and telemetering systems, automatic switchgear, electronic machinery controls are just a few of the applications where this new miniature Saginaw b/b Screw will solve critical positioning/control problems. *It's so compact and light,* you can save substantially on space and weight. *It's so efficient,* (over 90%) you can use much smaller motors and gear boxes. *It's so precise,* you can position components within .0005 inch per inch of travel. *It's so dependable,* you can rely on remarkably long service life even in adverse environments.

You will find our 1958 Engineering Data Book extremely helpful in planning applications, or experienced Saginaw engineers will gladly make specific recommendations without obligation. Just phone, write or mail the handy coupon.

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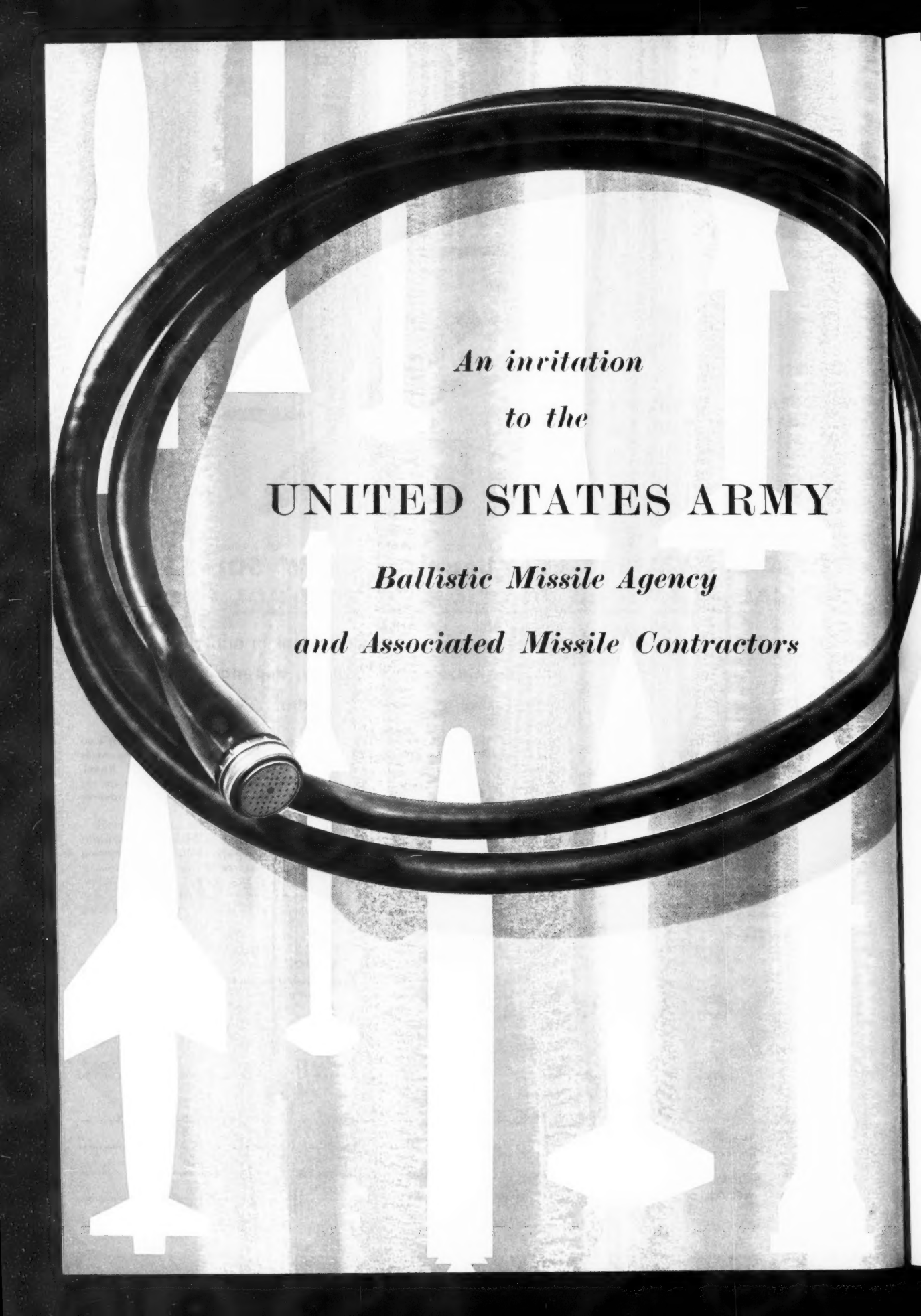


An invitation

to the

UNITED STATES ARMY

Ballistic Missile Agency

and Associated Missile Contractors

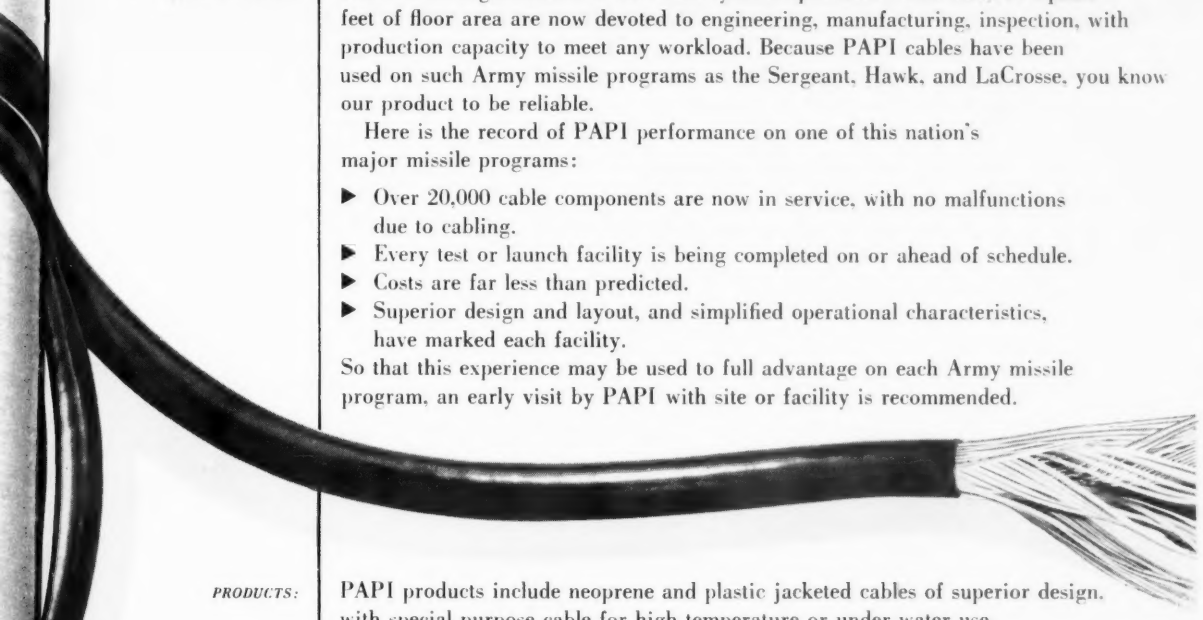
INVITATION: This is an invitation to utilize the missile systems engineering services of Pacific Automation Products, Inc., on current and upcoming Army missile programs.

QUALIFICATIONS: PAPI is an organization of 700 cable systems specialists. Over 150,000 square feet of floor area are now devoted to engineering, manufacturing, inspection, with production capacity to meet any workload. Because PAPI cables have been used on such Army missile programs as the Sergeant, Hawk, and LaCrosse, you know our product to be reliable.

Here is the record of PAPI performance on one of this nation's major missile programs:

- Over 20,000 cable components are now in service, with no malfunctions due to cabling.
- Every test or launch facility is being completed on or ahead of schedule.
- Costs are far less than predicted.
- Superior design and layout, and simplified operational characteristics, have marked each facility.

So that this experience may be used to full advantage on each Army missile program, an early visit by PAPI with site or facility is recommended.



PRODUCTS: PAPI products include neoprene and plastic jacketed cables of superior design, with special purpose cable for high temperature or under water use.

SERVICES: PAPI offers the following services in the cabling and activation of missile test and launch facilities: *Systems Design*—working from schematics, PAPI design engineers will determine every conductor that is needed to link block houses, control centers, terminal rooms, and stands or platforms. Cables are designed to effectively accommodate these conductors, and include break outs, connectors, and accessories. *Systems Fabrication*—cable assemblies leave our plant in ready-to-install condition, with rigorous quality control procedures governing every step of the fabrication process. *Systems Installation*—PAPI's experienced personnel and proven methods are utilized in field installation of all inter-unit cabling, instrumentation, recorders, transducers, controls, consoles, and accessories. *Systems Checkout*—PAPI specialists checkout all circuits for conformity to specifications, confirm the operation of each instrumentation system, and validate the fire and launch control functions. *Systems Documentation*—working drawings of the entire installation are supplied in approved form.

CONCLUSION: PAPI's engineering staff includes men with outstanding experience in every pertinent phase of the missile business. It is no accident, therefore, that we are the "take charge" sort of people who can take full responsibility for providing the services described in this message. We hope that you will accept this invitation and plan to utilize PAPI's great practical knowledge and experience in Army missile facility cabling and activation.

Arthur P. Jacob

ARTHUR P. JACOB, EXECUTIVE VICE PRESIDENT

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Astronautics

presents an editorial round-up of

INSTRUMENTATION and GUIDANCE in the MAY ISSUE

Planned by Dr. Simon Ramo, the dynamic Chairman of the American Rocket Society's Publications Committee and chief scientist of the Air Force ballistic missile program, this issue of ASTRONAUTICS will be a springboard for you into the multi-billion dollar instrumentation and guidance segment of the astronautical market. Editorially, it will be a round-up of the current state of the art, and the immediate future of instrumentation and guidance in the astronautical market — rockets, missiles, hypersonic aircraft and space vehicles — and will help ignite the creativeness of the best brains in the astronautical industry. Outstanding authorities will contribute articles featuring the best and latest developments in astronautical electronics.

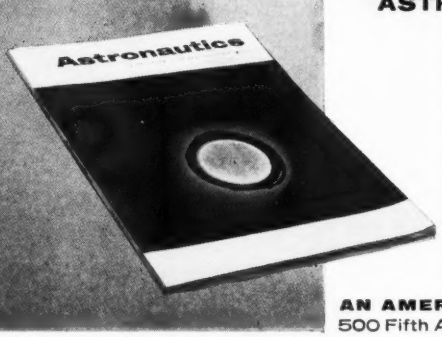
Fundamentals of Missile Guidance
By John R. Moore, Gen. Mgr., and Charles P. Greening, Staff Member, Adv. Eng. Dept., Autonetics Div., North American Aviation

Missile Guidance by Infra-Red
By Raymond H. McFee, Research Dir., Avionics Div., Aerojet-General Corp.

Three Problems in Radio Telemetry
By M. H. Nichols and L. L. Rauch, Univ. of Michigan

Instrumenting for Large-Scale Captive Missile Testing
By R. H. Ackley, Tech. Staff Asst. to Asst. Chief Eng. — Field Test, Convair-Astronautics

plus articles on radar, computers and simulators, inertial guidance, radio guidance techniques and others.



memo to the sales-minded

ASTRONAUTICS gives you virtually 100% coverage of the truly important men in the industry . . . engineers, scientists and executives who plan, conceive, design, build and utilize today's — and tomorrow's — rockets, missiles, hypersonic aircraft and space vehicles.

They are vitally concerned with every phase of astronautical design — including electronic components, guidance systems, instrumentation and controls. In short, you must sell them before the sale can be made, for they are the primary specifying factors. And the one best place to tell-and-sell them is through the advertising pages of ASTRONAUTICS.

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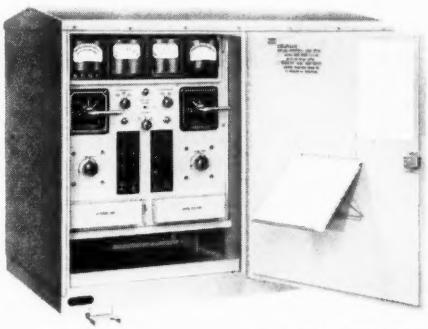

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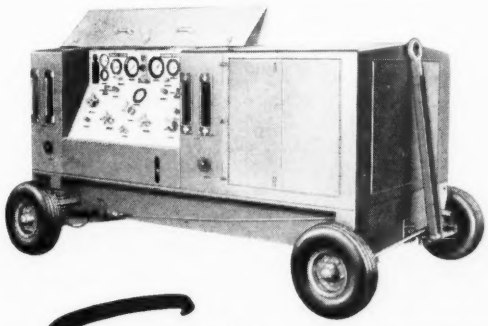

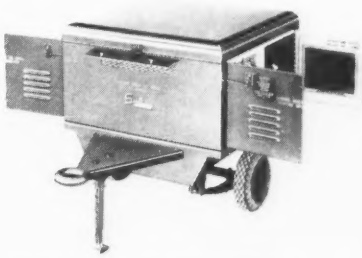

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ARS news

Astronautical Exposition Planned for L. A. Meeting

The first of two 1958 ARS Astronautical Expositions will be held during the Semi-Annual Meeting in Los Angeles, June 8–12. The Exposition will take place June 9–11 at the Hotel Statler, adjacent to the ARS meeting rooms.

Some 12,000 square feet of exhibit space in the hotel's Wilshire and Assembly Rooms on the Mezzanine Floor will be occupied by the exhibits. The second such Exposition is planned for the Hotel Statler in New York during the Thirteenth Annual Meeting, November 16–21.

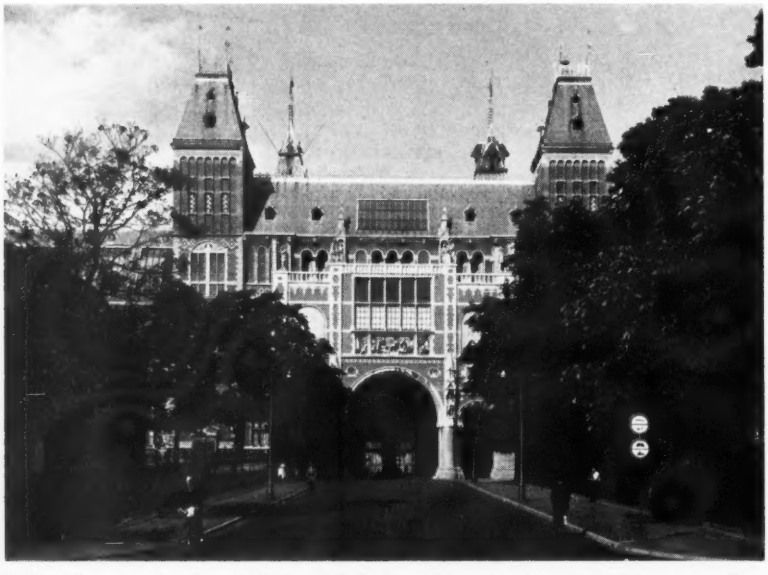
Howard S. Seifert, Program Chairman, announced that two of the sessions planned for the June meeting will be classified—one on Missile Launching Operations, the other on Rocket Engine Systems. Organizing the sessions are Herbert L. Karsch; Aeronutronic Systems, Inc. (Missile Launching Operations) and Y. C. Lee, Aerojet-General (Rocket Engine Systems).

Other sessions are being assembled by: W. H. Pickering, Jet Propulsion Laboratory (What IGY Has Told Us About Space); Peter Weiser, Ramo-Wooldridge (Operations Research in Missile Engineering); Krafft Ehricke, Convair-Astronautics (Lunar and Cislunar Satellites and Space Vehicle Guidance); Mort Rosenbaum, Convair-Astronautics (Managing Experimental Missile Projects); Herbert Friedman, Naval Research Laboratory (Test Instrumentation); John F. Tormey, Astrodyne (Propellant Handling and Magnetohydrodynamics); Brooks Morris, Marquardt (Handling and Testing Rocket and Ramjet Engines); and Irwin Cooper, Rand Corp. (Bio-Satellites).

The first annual Western Regional Student Conference will be held during the meeting and is being organized by Andrew Charwat of UCLA.

Seek Funds for ARS Memorial to Goddard

Plans for the erection of a modest ARS Robert H. Goddard Memorial have been approved by the Board of Directors. Total cost of erecting the memorial has been estimated at about $2500, and the ARS general membership is being invited to send donations to the fund set up for this purpose. The memorial will be erected at Worcester, Mass., near the site where Goddard successfully fired the world's first liquid rocket engine in 1926, and possibly on the campus at Worcester Polytechnic Institute, where he did his early work.



Rijks Museum in Amsterdam will be tourist attraction for those attending Ninth IAF Congress

Outstanding Technical Program Shaping Up for IAF Congress

By Andrew G. Haley

An official bulletin concerning arrangements for the Ninth Annual Congress of the International Astronautical Federation has been issued by J. M. J. Kooy, vice-president of the IAF and chairman of the Nederlandse Vereniging voor Ruimtevaart. The announcement contains vital information for those who intend to participate in the Congress. Dr. Kooy writes:

"I take pleasure in informing you that the Ninth Congress will be held at Amsterdam, in the municipal University situated in the picturesque center of the town, during the week of August 25–30, 1958.

"Being aware of your great interest in the general field of astronautics, I am most honored to invite you to participate in this congress.

"For attending the Congress, a registration fee of f 60, including the costs of the excursion, will be charged. . . ."

"In order to produce a worthy program, we shall pay special attention to the papers. If you intend to contribute, send your treatise in due time, please.

"The committee in charge of the selection and admission of papers is composed as follows: Prof. F. Hecht, chairman; Dr. W. B. Klemperer, vice-chairman; Dr. E. Sänger; Prof. L. I. Sedov; Dr. L. R. Shepherd; Dr. J. A. Stemmer; Dr. J. M. J. Kooy.

Interesting Papers

Several interesting papers already have been promised for this Congress. Theodore von Kármán will present his "Magneto Fluid Dynamics in Relation to Space Flight Problems"; Eugen Sänger, "Sources of Radiation for Photonic Rockets." Ferdinand Cap will read two papers—"Astronautics and Relativity" (a short report on time dilatation in space flight, attainability of light velocity by space ships, gravitation, "Hein's mesofield" and space travel) and Prof. W. Gröbner's general and exact solution of the astronomical n-body problem and its application to astronautics. Irene Sänger-Bredt will discuss working fluids for rockets heated by nonconventional chemical energy; and S. F. Singer will present "Meteorite Defense for the Planet Earth."

In addition, papers from world renowned scientists who have achieved high distinction in the field of astronau-

tics and heretofore have not attended the IAF Congresses will present papers. Papers are expected from: Sin-I Cheng, Princeton University; Rudolph Herrmann, University of Minnesota; Joseph Hilsenrath, Bureau of Standards; J. H. Ruth, Rand Corp.; J. M. J. Kooy, Holland; Bernard Lewis, Combustion & Explosive Research, Inc.; Paul S. Lykoudis and Angelo Miele, Purdue University; Konstantin A. Nikitin, Soviet Academy of Science; Edward W. Price, Naval Ordnance Test Station; R. E. Roberson, Autonetics; Oscar K. Rice, University of North Carolina; Ernst Stuhlinger, ABMA; George P. Sutton, Rocketdyne; Wernher von Braun, ABMA; and H. Wagner, Technische Hochschule, Aachen, Germany.

ARS papers are being reviewed by the ARS Program Committee. Manuscripts should be forwarded to the Committee at ARS Headquarters, 500 Fifth Ave., New York 36, N. Y. Deadline for papers is April 30.

Special ARS Flights To IAF Congress Set

Two KLM Royal Dutch Airline flights are being arranged especially for ARS members and guests attending the Ninth IAF Congress in Amsterdam. The flights will depart from New York on Wednesday, August 20 and Saturday, August 23.

For bookings, as well as for hotel reservations in Amsterdam and information on post-meeting tours, fill out and return the coupon on page 62.

° ° °

As president of the International Astronautical Federation, I am making an organizational and informational tour of Europe taking me to Dublin, London, Brussels, The Hague, Paris, Madrid, Barcelona, Rome, Athens, Cairo, Jerusalem, Belgrade, Zurich, Stuttgart, Loccum, Prague, Warsaw, Moscow, Leningrad, Helsinki, Stockholm, Oslo, Copenhagen and Amsterdam.

Several of these visits will be in connection with the holding of organizational meetings of new astronautical societies.

Klemach Heads Detroit Meeting

Fred A. Klemach, senior staff engineer, specializing in missile applications at Vickers, Inc., Detroit, has been named chairman of the ARS Fall Meeting, to be held Sept. 15–18 at the Hotel Statler in Detroit. Announcement of the appointment was

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made by Howard S. Seifert, ARS national Program Chairman.

Klemach, former president of the Detroit Section, will chair the executive committee which includes Charles W. Tait of Wyandotte Chemicals Corp. and Lovell Lawrence, Chrysler Missile Div. and current president of the host Section.

Plans for the technical program, being organized by the ARS Technical Committees under the coordination of Dr. Seifert, call for the following sessions:

1. Missile Fabrication Techniques.
2. Reliability of Long-Range Missile Components.
3. Forum on Industry Applications of Knowledge Gained in Space Flight Research.
4. Controls for Supersonic Air-breathing Engines.
5. Monopropellants.
6. Missile Production Problems.
7. Auxiliary Power Supplies.
8. Missile Logistics.

Those wishing to submit papers for the sessions should send 100–200 word abstracts to the Program Chairman, AMERICAN ROCKET SOCIETY, 500 Fifth Ave., New York 36, N. Y., before June 1.

At Alabama Section Board Meeting

Alabama Section members present at a recent board meeting are: Front row (left to right): Cliff Fitton, past-president and director; Rod Stewart, vice-president; Dave Newby, president; Bob Whitley, treasurer; Jim Lee, secretary; Back row (left to right): Bill Davis, director, Gordon Artley, director; Conrad Swanson, past-president and director; Gene McClard, director; Niles White, chairman of the membership committee; and Joe Bova, chairman of the program committee.

Chrysler Award Competition Announced

Entries for the 1958 competition for the ARS-Chrysler Corporation Student Award are now being invited, announces ARS Awards Chairman Kurt Stehling.

A $1000 stipend "to be used for educational purposes" will be awarded to the "graduate or undergraduate student" enrolled at an accredited university or college who submits the paper judged best on any subject related to astronautics. Deadline date

Western Student Conference Papers Eligible

Papers submitted for the 1958 ARS Western Regional Student Conference will be considered automatically as entries in the 1958 competition for the ARS Chrysler Award, announces Kurt Stehling, Awards Committee Chairman.

The following west coast faculty members have been appointed to the reviewing committee for papers for this Conference by Howard S. Seifert, Program Chairman:

Andrew F. Charwat, (Chairman)
Associate Professor of Engineering
University of California
Los Angeles 24, Calif.

Frank E. Marble
Associate Professor
California Institute of Technology
Pasadena, Calif.

E. V. Laitone
Professor of Mechanical Engineering
University of California
Berkeley, Calif.

The Conference is scheduled for June 9 at the Hotel Statler in Los Angeles. It will take place during the ARS Semi-Annual Meeting and Astronautical Exposition June 8–12 at the same hotel.

Entry forms for the conference can be obtained from the members of the reviewing committee or directly from the ARS office, 500 Fifth Ave., New York 36, N.Y.

Completed manuscripts must be submitted to Professor Charwat before *May 1, 1958*. Other details are included in the announcement on page 52.

for manuscripts is *August 15, 1958*. Manuscripts should be forwarded to 1958 Chrysler Award Competition, AMERICAN ROCKET SOCIETY, 500 Fifth Ave., New York 36, N.Y. Entry forms should be requested from the same address.

Winner of last year's award was J. Reece Roth, a junior at Massachusetts Institute of Technology, with a paper entitled "An Application of Particle Dynamics to the Measurement of Rocket Exhaust Velocity."

SECTIONS

Alabama: The Alabama Section has established nine committees and named chairmen, as follows: Arrangements, M. D. Anderson; awards, Rod Stewart; education, W. A. Davis; intersociety relations, Conrad D. Swanson; historian, T. E. McClard; membership, N. C. White; newsletter, G. A. Deuel; program, W. L. Berry Jr.; and publicity, C. T. Paludan.

The anniversary celebration marking the second birthday of the Army Ballistic Missile Agency on Feb. 1 turned into a real gala, coming as it did on the heels of the successful Explorer launching. An ABMA open house was held and special events included a parade, static firing of a rocket engine, exhibits of guidance equipment, a display of the Redstone and Jupiter missiles, tours of a lox plant and the static test area, and a demonstration of how a Redstone is loaded into an aircraft.

The Section has recommended Cliff E. Fitton Jr., past-president and present board member, for the Huntsville "Young Man of the Year" Award, made annually by the Huntsville Junior Chamber of Commerce.

Dieter K. Huzel, assistant group leader of engine systems experimental development for Rocketdyne, was the guest speaker at the February meeting, presenting a classified talk on large liquid propellant rocket engines. He also showed an interesting film picturing the steady progress that has been made in rocketry.

Huzel

A teen-age group has been organized in Huntsville as a Junior Rocket Society. Guidance for the group is being provided by individual members of the Section.

—Charles T. Paludan

Antelope Valley: Fritz Zwicky was the guest speaker at the Section's January open meeting, attended by about 180 members and guests. Dr. Zwicky's topic was "First Shots into Interplanetary Space," and in his address he described the shaped charges used in the Air Force experiment last year in which small aluminum pellets were propelled into space. Dr. Zwicky told how the aluminum pellets were treated so as to glow in the rarefied upper atmosphere when impinged upon by free ions.

The University of California's Space Technology course is being given in the Antelope Valley area, and has attracted an enrollment of well over 600. Students are drawn from contractors on the Hill, as well as from the main base at Edwards, and include a few residents of the valley having no connection with rocketry.

—Frank V. Zappa

Cleveland-Akron: Lt. Col. I. O. Winfree, chief of the ARDC Guidance Branch, was the guest speaker at the Section's January meeting at the NACA Lewis Flight Propulsion Laboratory. Col. Winfree's topic was "Long-Range Missile Guidance," but in his talk he also touched on space flight guidance problems and techniques.

At the previous meeting, J. J. Nassau, the distinguished astronomer of the Case Institute of Technology, presented his candid observations on such subjects as the Soviet satellites, astronomy and the Russian educational system. Especially interesting were Dr. Nassau's impressions of the latter, obtained while traveling in Russia last year. He noted that the contrast between the U.S. and Soviet systems becomes very vivid in the light of the fact that in Russia "knowledge means power" is being superimposed on the idea of "learning for the love of learning."

Many Section members attended the classified IAS annual propulsion meeting held in Cleveland last month. Sessions were devoted to air-breathing engines, nuclear engine technology, rocket technology and rocket systems.

—Harold W. Schmidt

Columbus: The February meeting of the Section was addressed by I. J. Weisenberg, senior project engineer, Reaction Motors. He introduced his talk on problems associated with the design of injectors and combustion chambers by running through the different types of injectors and the various design methods used. He pointed out the problems involved in a kinetic approach to injector design, owing to the large number of variables and their interdependence.

Weisenberg

Two reels of high-speed motion pictures were shown as one approach to realizing a better understanding of the combustion process within a combustion chamber. A lengthy question-and-answer period followed the talk.

Earlier, Harold Rienstra, Section representative to the Youth Guidance Committee of the Columbus Technical Council, requested the cooperation of individual members in working with the committee in assisting high school science programs.

The meeting concluded with a showing of Rocketdyne's "Road to the Stars" film.—**James L. Harp**

Connecticut Valley: Recent Section meetings, addressed by Martin Summerfield of Princeton University and Leon Trilling of MIT, attracted large audiences. Dr. Summerfield's talk on "Satellites and Sputniks," a popularized version of his articles on this subject in ASTRONAUTICS, brought out an attendance of more than 150 people, including a number of the wives of Section members, indicating that satellites have more or less become a breakfast conversation topic.

Dr. Trilling's discussion of Soviet education and research in astronautics was also well attended, and attracted a number of people who, although not Section members, were interested in the subject. He presented a detailed comparison of the U.S. and Soviet technical education systems, and also commented on Soviet foreign policy and the Russian social structure.

The 1957 officers of the Section were re-elected to a second term. They are: Charles H. King Jr., Combustion Section, United Aircraft Corp., president; C. W. Lemmerman, president of C. W. Lemmerman, Inc., vice-president; W. D. Viets, Fuller Brush Co., treasurer; and Sheldon Dolinger, research engineer, UAC, secretary.

—Sheldon Dolinger

Minnesota: Section officers for 1958 are: T. F. Irvine, Mechanical Engineering Dept., Univ. of Minnesota, president; J. E. Barkley, director of research, Mechanical Div., General Mills, vice-president; T. E. Murphy, M.E. Dept., Univ. of Minnesota, secretary; and J. B. Hatcher, treasurer.

National Capital: Col. R. E. Coffin of the Army R&D staff was the guest speaker at a recent meeting of the Section. Col. Coffin's topic was "Beyond the Air Age."

Lt. Col. C. M. Parkin Jr., chairman of the Section's Advisory Committee for missile and rocket amateurs, reported on the committee's progress at the meeting. Col. Parkin announced

on the calendar

1958

April 3, 10, 17, 24	Gas Dynamics Colloquium, Technological Institute, Northwestern U., Evanston, Ill.
April 17–18	Second Annual Meeting of Institute of Environment Engineers, Hotel New Yorker, N.Y.C.
April 22–24	1958 Electronic Components Conference, sponsored by IRE, AIEE, EIA, Ambassador Hotel, Los Angeles.
April 27–May 1	60th Annual Meeting of American Ceramic Society, Penn-Sheraton Hotel, Pittsburgh, Pa.
April 28–30	Second Annual AFOSR Astronautics Symposium, Denver, Colo.
May 1, 8, 15, 22, 29	Gas Dynamics Colloquium, Technological Institute, Northwestern U., Evanston, Ill.
May 4–7	Fourth National Instrumentation Flight Test Symposium of ISA, Park Sheraton Hotel, NYC.
June 2–4	**National Telemetering Conference under auspices of ARS, IAS, AIEE, ISA, Lord Baltimore Hotel, Baltimore, Md.**
June 8–12	**ARS Semi-Annual Meeting, Hotel Statler, Los Angeles, Calif.**
June 16–18	Second National Convention on Military Electronics, sponsored by IRE, Sheraton Park Hotel, Washington, D. C.
June 19–21	**Heat Transfer and Fluid Mechanics Institute Meeting, University of California, Berkeley.**
June 23–July 3	Special Summer Program in Random Vibration, MIT, Cambridge, Mass.
June 25–27	1958 Air Transportation Conference, sponsored by AIEE, Statler Hotel, Buffalo, N. Y.
Aug. 13–21	10th Assembly of the International Astronomical Union at Moscow.
Aug. 25–30	**Ninth Annual Congress of International Astronautical Federation, Amsterdam, The Netherlands.**
Sept. 1–7	1958 Farnborough Flying Display and Exhibition, Farnborough, England.
Sept. 15–18	**ARS Meeting, Hotel Statler, Detroit, Mich.**
Sept. 22–24	IRE National Symposium on Telemetering, the American Hotel, Bal Harbour, Miami Beach, Fla.
Sept. 24–25	National Electronics Conference, sponsored by IRE, AIE, EIA, Hotel Sherman, Chicago.
Nov. 10–13	AF School of Aviation Medicine-Southwest Research Institute Space Flight Symposium, San Antonio, Tex.
Nov. 16–21	**ARS 13th Annual Meeting, Hotel Statler, New York, N. Y.**

that Aerojet-General had made a cash contribution to the committee for use in aiding a youth rocket group at Washington and Lee High School in Arlington, Va.

Northern California: S. Fred Singer of the University of Maryland was the guest speaker at the January dinner meeting of the Section, held at the Marines' Memorial Club in San Francisco. Dr. Singer spoke on "Research at Extreme Altitudes Through the Use of Rockets." His stimulating description of the objectives and means of such research was of great interest and resulted in a lively question-and-answer period in which the 100 members and guests present participated.

Newly elected officers of the Section for 1958 are: Comdr. E. A. Quarterman, president; James S. Arnold, vice-president; Bernard Ellis, secretary; and C. F. Hansen, treasurer. Immediate past-president A. K. Oppenheim has been elected a director to serve to 1961.

San Diego: Gerald Morrell, head of the Rocket Chemistry Branch of the NACA Lewis Flight Propulsion Laboratory, addressed about 75 members and guests at a meeting in the IAS building. Since he was on an official tour of scientific laboratories, he spent some time in an informal discussion of the shortcomings and problems of scientific research in this country. The key to the problem, he felt, was economics. Basic research cannot be successfully carried out under a yearly contract; it is too often over-organized in an effort to produce and the public has too little respect for scholarship dissociated from financial success.

In his prepared address, he dealt with some basic liquid rocket combustion problems, pointing out some of the unknowns in the physical process of burning droplets in a violent atmosphere, and discussing flame kinetics, resonance with resultant high heat transfer, and circulation of the boundary layer in a combustion chamber. **—Daniel A. Heald**

STUDENT CHAPTERS

Fenn College: The Fenn Chapter, formed in the fall of 1957, now has 40 members. Faculty advisor for the chapter is Albert M. Lord of the college's Mechanical Engineering Dept.

Recent chapter activities included a field trip to the NACA Lewis Flight Propulsion Laboratory rocket facilities and a dinner meeting at which A. O. Tischler of Lewis, former Cleveland-Akron Section president, spoke on "Application of Rockets in IGY Studies."

Georgia Tech: New officers of the chapter, to serve during the 1958 spring and summer semesters, are James C. Ludwig, executive chairman; Robert B. Starrett, executive vice-chairman; Norman W. Swain, recording secretary; Frank E. Swalley, corresponding secretary; and Howard M. Bradner, treasurer.

University of Virginia: Robert L. Wolf, vice-president of Experiment, Inc., was the guest speaker at a recent joint meeting of the chapter with the IAS. His topic was "Solid Fuel Ramjets."

New officers of the chapter are H. Duane Evans, president; Marshall I. Levy, vice-president; and M. D. Miller, treasurer. Stuart L. Croll continues as secretary.

TECHNICAL COMMITTEES

Human Factors: Several papers of interest were presented at the Symposium of Space Medicine held in conjunction with the AAAS meetings in Indianapolis. Maj. David G. Simons and Capt. Erwin Archibald of the Aero Medical Field Laboratory, Holloman AFB, delivered papers on Maj. Simons' Manhigh II flight; Capt. Grover J. D. Schack of the Laboratory presented a paper on optical illusions during the flying of sub-gravity trajectories, and James Gaume, now of The Martin Co., Denver, offered a paper on space cabins and sealed cabin environments.

In January, Capt. Schack completed work on his doctoral thesis at the University of Illinois. His thesis, dealing with orientation and illusion in sub- and zero-gravity conditions, is believed to be the first ever accepted on a subject in the space medicine category.

Minneapolis-Honeywell Corp. now has a human factors group, headed by John W. Senders, formerly associated with the AF Aero Medical Laboratory at Wright Field and the Aero Medical Laboratory in Alaska. O. H. Lindquist is a member of the biophysics and physics branches of the group, while R. L. Cross is in the industrial design section.

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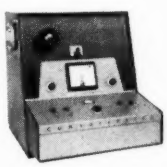

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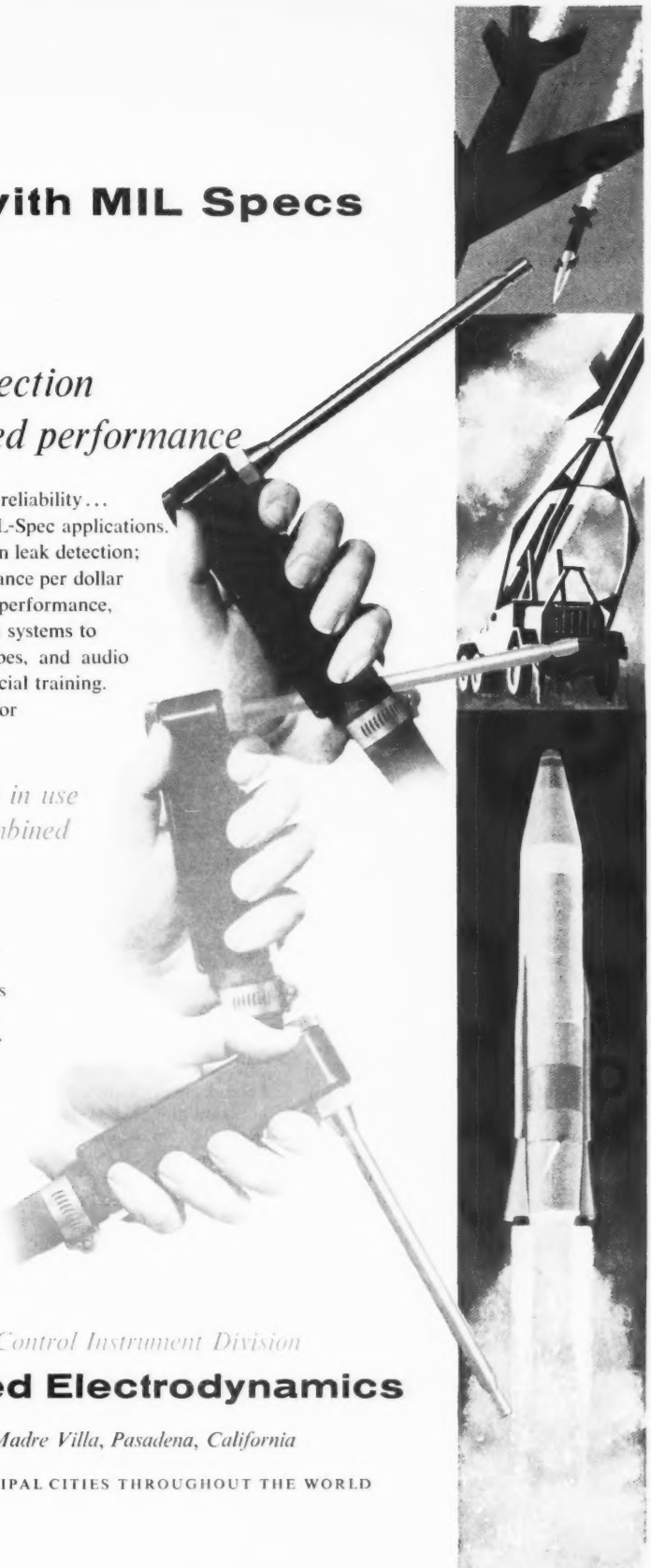

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The Sergeant missile has outranked the Corporal as the U. S. Army's new surface-to-surface tactical ballistic guided missile. The promotion came after tests at White Sands Proving Ground, N. M., proved the Sergeant an extremely mobile weapon, able to do the same job as the Corporal, only a great deal better.

An Army fact sheet revealed that the Sergeant stands approximately 30 ft high, utilizes a Thiokol solid propellant rocket motor and has a range of close to 200 miles, compared with the Corporal's 75- to 100-mile range.

The Army proudly stated that "for the first time we have a big missile that can be quickly emplaced and fired by a very small crew under all conditions." (The Corporal battalion has 250 men.) In addition, the Sergeant can deliver a nuclear warhead deep behind enemy lines and "has a highly accurate guidance system invulnerable to any known means of enemy countermeasures."

The missile was designed and developed by the Jet Propulsion Laboratory. Sperry Gyroscope Co. produces the complete missile system.

AFCRC

(CONTINUED FROM PAGE 42)

Much of this propagation work is tied up in classified programs at present. Some of these programs, it is admitted, relate to missile guidance and control, as well as detection.

The Propagation Lab is also carrying out work in radio astronomy. One such project is the 84-ft radio telescope at Ipswich, Mass., one of the largest in this country and comparable to England's new 250-ft unit, which the lab also hopes to use, under contract, for its work. Again, the objective is to learn more about signal propagation.

Radar Laboratory

The Radar Laboratory is not long for ERD. Most of the work in this section centers on development of radar components, and the feeling at ERD is that this work more properly belongs at Rome ADC.

In its place, the directorate plans to establish a new laboratory to do research on detection techniques. It would not limit itself to radar systems as such, but would investigate all new scientific developments with an eye to roles they might play in some new, and possibly unconventional, detection scheme. The current feeling at ERD is that this group would go deeply into such fields as plasma, microwave and extremely high-temperature physics.

Communications Laboratory

Longer range and more reliable and secure AF communications are the goals of scientists in the Communications Laboratory. In addition, the lab is concerned with the problem of channel capacity. There is just not enough space for all civilian, military and commercial transmission needs.

Much of its work is aimed at increasing the range of air-to-ground communications. To date, scientists using scatter techniques in specially instrumented aircraft have extended the range to 1800 miles.

The lab also has one group of researchers who study and develop principles of cryptographic analysis, and then synthesize these principles into complete new cryptographic systems. Another group conducts research in advanced transistor theory and techniques. Still another branch of the lab is concerned with vocal transmission. This group is looking for common speech patterns which can be coded (digitized) for transmission. Speech would then be reconstructed at the receiver, and would require only a tenth of the bandwidth normally needed.

One of the most recent projects to evolve from the lab is a control carrier and communication system. At present, in transmitting a radio signal between two points, more power is generally used than is actually needed. For example, 1 kw may be all that is needed 99.9 per cent of the time, while it may take 10 kw to get a signal through 0.1 per cent of the time. So standard practice is to use 10 kw all the time to be on the safe side. This results in wasted power, short-lived equipment, interference and widely scattered signals which may be picked up by the enemy.

To avoid all this, lab scientists came up with the idea of incorporating a feedback system which would turn up the power the one time in a thousand the extra power was needed. This is the principle behind the control carrier

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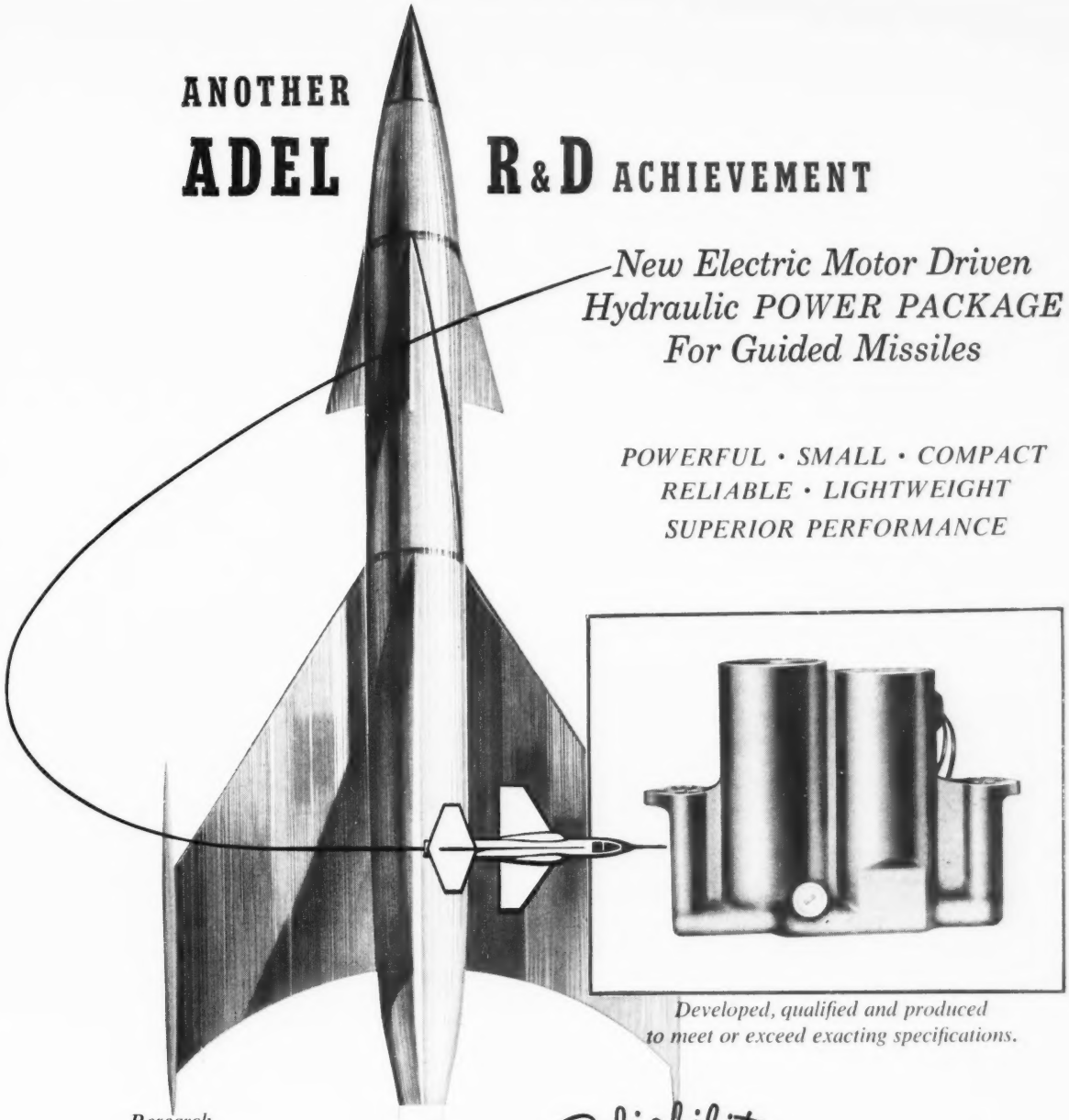

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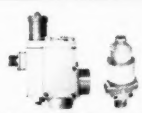

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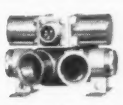

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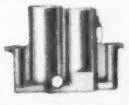


Electric Motor Driven Hydraulic Power Packages

and communication system. A study contract has been let to Westinghouse on the system.

Special Systems and Navigation Labs

The Special Systems and Navigation Laboratories are working on so-called "electronics ground environment systems"—large major networks of radar and communication, equipment and computers for the automatic tracking, guidance and control of aircraft.

The Special Systems Lab is developing the TAC (Tactical Air Control) System. As the name suggests, the customer for this system is the Tactical Air Command. The system, designed for mobility, will operate near the front lines and will direct tactical aircraft on interdiction missions behind enemy lines. It will also compute the best intercept courses and automatically guide fighters to enemy aircraft and back to base after the mission.

The Navigation Lab, on the other hand, is concerned with a system for more peaceful purposes—control of air traffic approaching a field for landing. The system being developed to do this is the VOLSCAN System. Like the TAC System, it is a highly complex, automatic network of radar and communication equipment built around a computer. Fully developed, it will be able to schedule and land 120 aircraft an hour, compared to the present maximum of 30 to 40.

Communications Laboratory

A more appropriate name for the Communications and Techniques Laboratory, suggests one ERD spokesman, would be the Materials Research Laboratory. The general belief at the directorate is that future advances in electronics will depend more upon new materials than on improved circuit design.

In tune with this belief, the lab has a number of special high-temperature furnaces, including two solar units, operating almost all the time to grow crystals of different materials. One of the most interesting materials to be developed is the ferrimagnetic garnet, grown from a variety of rare earth elements. It has already been tested for possible use in isolators, oscillators and switches. And, according to one ERD spokesman, it now appears that the garnet isolator will ultimately lead to a major advance in anti-ICBM radars.

Conceded to be the most "far out" group in ERD, the Components Lab definitely devotes a greater share of its efforts to basic research than any other ERD section. At the same time, of course, the group is not completely divorced from AF objectives, far in the future though it may be.

A good example of this is the lab's work in the high-temperature field under the direction of Heinz Fischer. Using the "pinch effect," Dr. Fischer has produced temperatures estimated at 300,000 C. In this experiment, a light many times more brilliant than the sun is also created.

At present, this high temperature is of no practical value to the Air Force. But the accompanying brilliant light is. This pulsed light source lends itself to a new type of radar in which light instead of RF energy is used.

A process for producing ultra-high purity silicon for electronic use is another outgrowth of the group's research. Impurities are reported to be only one part in 10 billion. Of possibly greater significance for missile electronics is the development of a silicon carbide rectifier which can operate at white-heat temperatures.

In addition to the development of new knowledge, the Components Lab is also interested in the dissemination of knowledge, and has served as the moving force behind various research conferences sponsored by AFCRC and attended by top scientists. One such conference took place last fall on the subject of "Growth and Evaluation of Single Crystals of Ferromagnetic Ceramics." Another, held recently at Bedford, covered "Extremely High Temperatures" and devoted one of its seven sessions to the problem of controlled thermonuclear reaction.

Non-Research Tenants

Rounding out AFCRC are the Lincoln Project Office, Operational Applications Laboratory, Directorate of Procurement, 6520th Test Group and 6520th Air Base Group. All non-research section, they nonetheless play important roles in the operation of AFCRC and the Air Force as a whole.

The principal job of the Lincoln Project Office is to handle the AF contract with Lincoln Laboratory. This, in turn, means monitoring and supporting of activities associated with the SAGE air defense system. One branch of LPO, for example, is concerned with integrating new air defense weapons into SAGE; another is responsible for integrating SAGE into associated electronic systems.

The Operational Applications Lab is basically a human engineering group. Its job is to take equipment and systems developed by AFCRC and make sure they can be operated efficiently by AF personnel.

As its name implies, the Directorate of Procurement is concerned with supply. It advises the AFCRC commander on procurement matters and provides over-all direction of the Center's procurement activities.

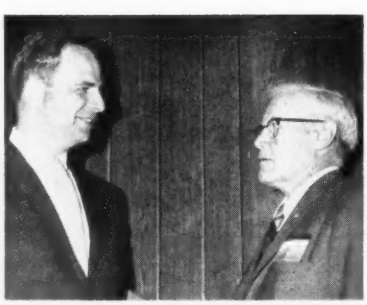
The 6520th Test Group, in addition to administrative and maintenance sections, is composed of four squadrons which execute experimental flights in support of research projects being carried out by AFCRC and Lincoln Laboratory. The 6520th Air Base Group, while it also has an Airborne Engineering Branch for support work, is primarily concerned with the operation of the AF base at Laurence G. Hanscom Field.

This, then, is the Air Force Cambridge Research Center. A strange outfit, as one journalist observed, made up of scientists, engineers, administrators, technicians and pilots divided into different groups without any apparent rhyme or reason.

But there is a common chord that ties AFCRC into one neat scientific package—the collection of knowledge. The mission of AFCRC is to learn as much as possible about flight, the medium in which it takes place and the conditions that affect it, with the ultimate aim of controlling all flight parameters. And now, with the first successful satellites, these men are in a hurry. There is a thousand-mile scientific void to be filled and little time left before this is turned into an interplanetary void. Man's ignorance is advancing rapidly.

It's the job of those at AFCRC to make sure his knowledge doesn't lag too far behind.

Science Session



George P. Sutton, left, chief of preliminary design, Rocketdyne and president of the AMERICAN ROCKET SOCIETY talks shop with Alan T. Waterman, director of the National Science Foundation at a recent science conference at Yale.

Explorer May Last 4 Years

Walter Haeussermann, chief of the ABMA Guidance and Control Laboratory, recently predicted that the Explorer will have a life-span of about four years.

Swedlow specializes in heat protection!

Silicones
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Epoxies
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Sheet materials
Molded parts
High temperature welded honeycomb core

The solution to your heat problem is in the following...

Swedlow's aluminum-metallized heat reflective laminates

1650°F

MINIMUM WEIGHT • MINIMUM BULK—By combining the principles of highly efficient reflectivity of aluminum-metallized surfaces with the low thermal conductivity of glass fabric reinforced plastic laminates, Swedlow's "—101" metallized coatings offer protection up to 1650° F. The metallic coating protects the base laminate from thermal degradation.

APPLICATIONS—In flat sheets, or molded into complex contours, these materials are suggested as highly efficient heat blankets for compartment insulation, valve protection, exhaust heat damping, and other applications where there is prolonged high temperature exposure.

Swedlow's silicone plastic laminates

650°F

Swedlow's X5G-138 and X5G-176 silicone base materials are available as flat sheeting or molded parts and offer protection up to 650° F.

Swedlow's X5G-138 provides maximum strength per unit of thickness and weight and is recommended for applications requiring flat sheets or simple contoured molded parts.

The X5G-176 laminate has slightly lower physical properties than X5G-138 but is recommended for applications requiring complex contours.

APPLICATIONS—Missile nose cones, exit cones, fins, stabilizers, adapter rings, closure rings, and similar uses. Applications in airstreams at missile speeds are possible.

Swedlow's high temperature welded honeycomb core

/2500°F /2000°F

HIGH STRENGTH-WEIGHT RATIO • HIGH RIGIDITY-WEIGHT RATIO • HIGH VIBRATION DAMPING • HIGH FATIGUE RESISTANCE—The use of high temperature honeycomb core is expanding rapidly in a wide variety of aircraft and missile assemblies and parts, particularly where such parts experience high engine temperatures, aerodynamic heating, and corrosive environments. On your production line, use of honeycomb core assemblies reduces the number of parts, simplifies fabrication and assembly, reduces tooling, floor space and over-all costs per pound, and cuts repair and rework. Face sheets may be brazed to the core by the user for use at temperatures approximating 2000° F., or adhesives may be used if temperatures do not exceed 500° F.

APPLICATIONS—Wherever structural strength and corrosion resistance are required at extreme temperatures... with light weight.

600°F

Swedlow's high temperature phenolic plastic laminates

STABLE PHYSICAL PROPERTIES UNDER HIGH TEMPERATURES—Swedlow's X4G-116 is a high-temperature phenolic laminate that offers unusual physical stability at high temperatures up to 600° F. It is available in flat sheets, and can be molded to complex contours.

APPLICATIONS—Fins, stabilizers, missile nose cones, adapter rings, closure rings, and similar applications. May be used in airstreams at missile speeds.

450°F

Swedlow's epoxy-plastic laminate

Swedlow's X6G-141 epoxy-plastic laminate gives the user an electrical insulating material resistant to fracture and warpage in installation, with characteristics of very low moisture absorption and high physical strengths over a prolonged temperature gradient. Approved under MIL-P-18177. Conforms to NEMA standards for type G-3 materials.

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Swedlow PLASTICS COMPANY

Los Angeles, California
Youngstown, Ohio
Please refer to Dept. 17

For short duration of time the temperatures given for the above materials may be raised appreciably. Each application must be considered individually.

Swedlow is continuing research in high-temperature materials of all types . . . reflective coatings, ceramics, plastics, metals.

A highly trained staff of engineers and technicians will be pleased to assist you on the use of these materials for high temperature service. Please contact the plant nearest you.

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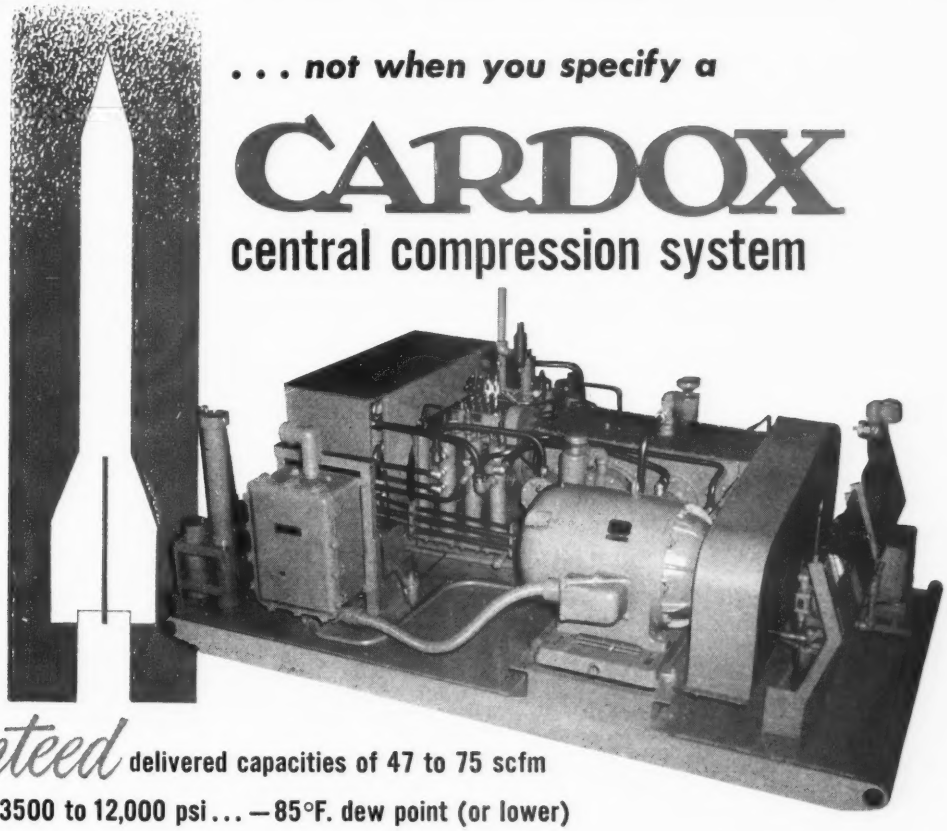

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CARDOX Central Compression Systems were perfected through the engineering and building of hundreds of compressors and their associated equipment, operating in the 12,000 psi range of high pressure pneumatics. In their most numerous use, these compressors supply the high pressure air used in mines instead of explosives to produce nearly 20% of all bituminous coal output of the U. S.

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RCCH oxide formulation gives "Type A" higher signal output and greater retentivity plus unique surface hardness for controlled tape wear rather than uncontrolled equipment wear.

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Talk or Action

(CONTINUED FROM PAGE 19)

anyway until the much-advertised reorganization of the Defense Department has actually been put into effect. When this will happen is hard to say.

Several noble men have tried to set up a space flight program with one or the other government organizations; however, most were administratively stopped. So they too must wait or risk going ahead without official approval and by scrounging funds from other projects. Some work is actually getting done by a few government agencies. The effort is small and rather poorly coordinated. For example, NACA, ABMA, various Navy groups, several AF centers and a number of contractors are proceeding with studies and investigations of technical space flight problems, each in its own program, and some with relatively little regard for the work of others. Whereas a national space flight program would orient these efforts toward the same goal.

One thing that has been done in this country has been the talking. Politicians, scientists and military people have said a lot about space flight but there have been mighty few new contractual commitments.

If we look at our national effort in space flight, we find it has been very slow, relatively uncoordinated and without unified direction. Many of us are resigned to waiting for Congress, the Defense Department and other Government agencies to make up their minds. Though the current mood in Capital circles seems to favor the creation of a civilian-controlled National Space Flight Agency, we are facing the unpleasant prospect of another delay—resolution of the conflicts between this civilian agency and the Department of Defense which has a very vital interest in astronautical matters. We are also confronted by prospects of continued jockeying between the various military organizations.

The ARS is dedicated to the evolution of space flight and we wish to see something done. We need a truly national program or set of space flight objectives and a clear definition of who is responsible (and perhaps more important yet, who is *not* responsible) for specific phases of the effort. We should have had these decisions many months ago.

If the U. S. becomes a second rate nation in space flight, it will not be because we lack capable technical men or resources, but because we waste effort and time. We lack inspired leadership rather than scientists.

—**George P. Sutton,** President
AMERICAN ROCKET SOCIETY

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ND FACTS

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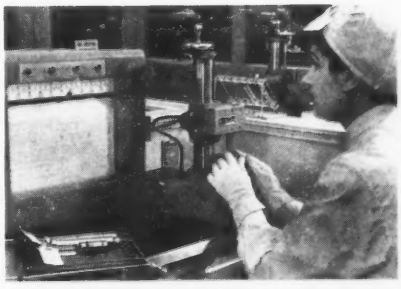
New Departure takes great pride in its ability to meet the exacting specifications of the products for the Army, Navy and Air Force programs.



Comparator measures dimensions to one-millionth of an inch. One of many pieces of ultra-precision equipment in the New Departure bearing laboratories.

In many bearings, various dimensions and surface finishes must be held to within tolerances of a few millionths of an inch.

1908–1958 GM FORWARD FROM FIFTY

ND NEW DEPARTURE

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NOTHING ROLLS LIKE A BALL

people in the news

Theodore von Karman, chairman emeritus of the USAF Scientific Advisory Board, has been named chairman of the new ten-man Scientific Advisory Committee set up by Allison Div. of General Motors, to assist in its R&D work on advanced propulsion systems. **Lawrence R. Hafstad,** vice-president in charge of the GM research staff, is vice-chairman.

Other members of the committee are **Luigi Crocco,** director, Guggenheim Jet Propulsion Center, Princeton University; **John R. Markham,** professor of aeronautical engineering, MIT; **Courtland Perkins,** chairman, Aeronautical Engineering Dept., Princeton; **William R. Sears,** director, Graduate School of Aeronautical Engineering, Cornell; **Maurice J. Zucrow,** professor of gas turbines and jet propulsion, Purdue; **Pol Duwez** and **W. Duncan Rannie,** professors of mechanical engineering, Cal Tech; and **Antonio Ferri,** professor of aerodynamics and head of aerodynamics laboratory, Polytechnic Institute of Brooklyn.

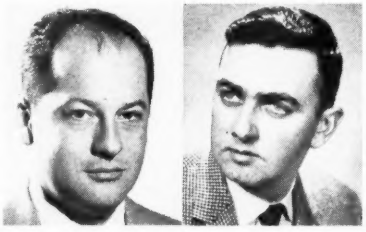
Newly appointed officers for Astrodyne, the new jointly owned company of North American Aviation and Phillips Petroleum, are **John F. Tormey,** former director of research, Rocketdyne, who will head development and engineering; **Richard J. Martinelli,** former assistant manager of manufacturing, Phillips' Rocket Fuels Div., to head manufacturing; **R. L. Storer,** former quality control manager for Phillips, the same post at Astrodyne; and **George F. Emerich,** former group leader on solid propellants for Rocketdyne, to be plant engineer.

Sadler **Olson**

Carl L. Sadler, general manager, Sundstrand Aviation Div., Rockford, Ill., has been promoted to vice-president of the division. **Richard H. Olson,** general manager of the former Aviation Div., at Denver, Colo., becomes vice-president of the new Sundstrand-Turbo Div.

Roy P. Jackson has been appointed assistant to Ernst H. Krause, vice-president of Aeronutronic Systems, Inc. Jackson had been chief engineer, Northrop Div. of Northrop Aircraft.

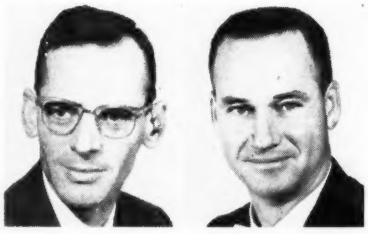
Fred P. Adler, senior staff physicist, Hughes Aircraft Co., is now manager, advanced planning staff, systems development laboratories.



Adler **Roberts Jr.**

Charles S. Robert Jr., formerly project engineer, Thiokol Chemical Corp.'s Redstone Div., becomes chief project manager, Thiokol's Utah Div.

C. M. Whitlock will assist James D. Ryan, chief physician for astronautics, Convair-Astronautics in space medicine research.

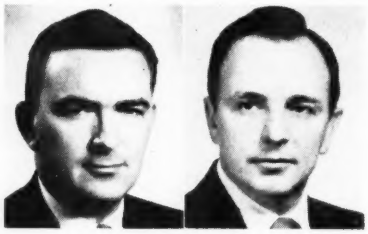


Saffell **Dailey**

H. R. Saffell will manage the newly formed Wiancko Aeronautics Div. of Wiancko Engineering Co., which will specialize in fundamental and applied research in high speed aerodynamics and propulsion. Chief engineer of the division is **C. L. Dailey.**

Lawrence Levy, president, Allied Research Associates, Inc., has been elected a director of Vertol Aircraft Corp., which recently acquired Allied Research.

Fred A. Klemach, former president, National Design and Research Corp., and past-president and director of the Detroit Section, AMERICAN ROCKET SOCIETY, has been appointed senior staff engineer specializing in missiles at Vickers, Inc.



Levy **Klemach**

W. C. House, former manager, Aerojet-General's Liquid Engine Div., has been made director of the newly established Aerojet Systems Div. **C. A. Gongwer** has been appointed associate director, but will continue as manager, Underwater Engine Div.

NACA has announced a number of appointments to technical committees and subcommittees. **Harold W. Ritchey,** technical director, Thiokol Chemical Corp.'s Rocket Divs., has been named to the subcommittee for the development of rocket engines; **Chandler C. Ross,** vice-president, engineering, Aerojet-General, to committee on powerplants for aircraft and chairman of the subcommittee on rocket engines.

Other Aerojet personnel named to NACA posts are **Richard D. Geckler,** manager, solid rocket plant, Sacramento, to subcommittee on engine performance and operation; **Rear Adm. R. S. Hatcher** (USN-Ret.), advance planning group, to subcommittee on seaplanes; **Gordon Banerian,** manager, Turbo-Machinery Div., to subcommittee on compressors and turbines; and **Yuan C. Lee,** director, research and planning, to subcommittee on combustion.

William H. Avery and **E. A. Bonney,** supervisors of research and development groups at The Johns Hopkins University Applied Physics Laboratory, also have been named to NACA subcommittees. **Don L. Walter,** vice-president, Marquardt Aircraft Co., will serve as chairman of the subcommittee on engine performance and operation, and on the committee on aircraft powerplants. Marquardt engineers **John A. Drake,** director, ASTRO Div., has been named to the subcommittee on internal flow; **William G. Bennet,** to subcommittee on combustion; and **R. T. Dungan,** to subcommittee on powerplant controls.

F. N. Darmara, general manager, Utica Metals Div., Kelsey-Hayes Co., will serve on the NACA subcommittee on powerplant materials. **Alexander Kartveli,** vice-president, research and development, Republic Aviation Corp., has been reappointed to the NACA committee on aerodynamics. Other Republic personnel named are **William J. O'Donnel,** chief engineer, aircraft and missiles development, to committee on flight and safety, and **Albert Epstein,** chief de-

sign requirements engineer, to committee on aircraft loads. **Rudolf H. Thielemann,** chairman, Stanford Research Institute Metallurgy Dept., has been reappointed chairman, subcommittee on powerplant materials.

Temco Aircraft Corp. has named **A. R. Teasdale,** chief of avionics, to the newly created post of director of advanced technology.

Olin Mathieson Chemical Corp. has named **Warren P. Turner** special assistant to L. Kermit Herndon, vice-president, High Energy Propellants Div. Turner was formerly director, Applications Engineering and Contracts Div., Reaction Motors, Inc.

Turner **Lehne**

Henry Lehne has been appointed vice-president of the Electronic Systems Div. of Sylvania Electric Products Inc. Lehne will direct contractual work on the Plato anti-missile missile system, and other projects.

E. U. Da Parma has been appointed executive vice-president, Sperry Gyroscope Co., moving up from vice-president for operations, Product Divs.

David R. Hull, vice-president and general manager, Raytheon Mfg. Co.'s equipment operations, has been promoted to the new post of vice-president for defense programs.

Ray P. Whitman, first vice-president, Bell Aircraft Corp., has been named general manager, Niagara Frontier Div., a newly established unit responsible for all Buffalo and Niagara frontier defense products activities. **Roy J. Sandstrom** will plan and direct all Bell projects pertaining to satellites and space travel. Reporting directly to Whitman will be vice-president **Julius J. Domonkos,** general manager, Aircraft Div.; Sandstrom, in his new capacity; **Glen R. Lord,** manager, Special Weapons Div.; **John H. vanLonkhuyzen,** manager, Avionics Div.; and **William M. Smith,** manager, Rockets Div.

Harold R. Sennstrom, vice-president, engineering, American Bosch Div., has been named vice-president, engineering and sales, and has assumed the additional responsibility for all division sales operations. **Stanley M. Terry** has been elevated to manager of engineering.

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REG. T.M

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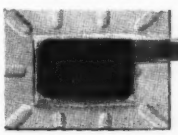
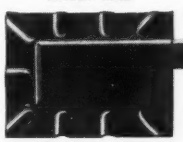


CEMENT-ON*, Type 1375

The temperature sensing element is encased by a die-formed wire screen which can be installed on any surface with TRANS-SONICS Type 64C cement.

TYPE	TEMPERATURE RANGE
1375A	−300 to +650F.
1375B	0 to 1000F.
1375C	+200 to 1250F.
1375D	+500 to 1550F.

actual size



WELD-ON*, Type 1376

The temperature sensing element is encased in a thin die-formed metal cover, and is installed by spot welding the cover to the underlying metallic surface.

TYPE	TEMPERATURE RANGE
1376A	−300 to +650F.
1376B	0 to 1000F.
1376C	+200 to 1250F.
1376D	+500 to 1550F.

- **RANGES:** From −400F to +1550F.
- **OUTPUT:** Up to 5 volts without amplification
- **RESISTANCE CHANGE:** 100 ohms over calibrated range.
- **ACCURACY OF CALIBRATION:** ±1% of range interval
  ±2% for temperatures over 1000F.
- **MAXIMUM CONTINUOUS CURRENT:** 20 milliamperes rms.
- **REPEATABILITY:** ±0.2% of range interval
- **VIBRATION:** 1-inch double amplitude, 0-22 cps;
  25g, 22-2000 cps.
- **ACCELERATION & SHOCK:** 100g on all three major axes
- **LEADS:** Two 6" nickel wires with high temperature insulation.

Trans-Sonics Cement-On Type 1375 and Weld-On Type 1376 Surface Temperature Transducers are platinum resistance thermometers that can be installed on any surface, flat or curved, metallic or non-metallic, for accurate temperature measurement. The protective cover of the resistive element is cemented or welded directly to the thermal surface to form an isothermal system which gives a transducer reading that corresponds to the true skin temperature.

A 5 point resistance-temperature calibration certificate at 0, ¼, ½, ¾ and full scale temperature is supplied with each transducer. A strip of aluminum Thermotape* is also furnished with each unit to provide an alternate means of tape-on installation useful to 800F and under limited conditions to 1000F.

Types 1375 and 1376 are the newest members of the Trans-Sonics family of platinum resistance thermometers for measuring surface temperatures. All units are capable of delivering up to 5 volts without amplification. Write to Trans-Sonics, Inc., Dept. 14, Burlington, Mass. for Technical Bulletin on Surface Temperature Transducers.

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From Drones to Space Flight

(CONTINUED FROM PAGE 39)

ratios up to about 10 because of its simplicity and reliability, and that, above a thrust ratio of 10, the only choice is dual thrust.

Also in this session, W. F. Haite of Thiokol turned his attention to the safety rules governing the storage of solid propellants, which, perhaps by force of tradition, have been classed as materials that can be expected to detonate in a fire or are subject to detonation en masse from the localized action of an explosive initiator, and consequently must be isolated and shielded from normal community and traffic. The author believes that composite propellants with ammonium perchlorate can be classed as high-temperature burnables that will not sustain a detonation wave. Similar arguments have been advanced for double-base propellants. Because it may be necessary to store missiles with as much as 250,000 lb of propellant each near population centers, this subject is far from academic.

Action for Drones

"Good things come in small packages"—that might have been the theme for the session on target drones. The need for high-speed practical drone aircraft has pushed the development of flexible, reliable and cheap rocket engines. These engines may well be precursors to economically practical commercial engines.

Arthur Sherman, manager of Reaction Motors' Market Research Dept., pointed out in his paper, "Advances in Rocket Propulsion Systems for Target Aircraft," that his company has produced a liquid bipropellant engine costing only 2 cents per lb per sec for total thrust delivered. The propellants can be factory-loaded into tanks, the tanks sealed, and the propellants thus stored for many years with no special handling or servicing. These loaded tanks can be shipped as inflammables under ICC regulations. The engine itself can be modulated in thrust, mounted in groups for greater power and can operate continuously for almost a half-hour. The motor can be taken "off the shelf" and reused many times.

H. H. Isaacs and J. O. Matzenhaur of Rocketdyne presented a thorough analysis of rocket-engine selection and design for a drone. They generally favor a liquid-propellant engine, choose red fuming nitric acid inhibited with hydrofluoric acid and unsymmetrical dimethyl hydrazine as the most advantageous propellants, and offer this comment on reliability:

"Pumped liquid systems, more complicated than pressurized systems for drones, have achieved over-all reliabilities above 96 per cent in less than two years of development and operation. Pressurized systems, designed with only six moving parts, would achieve reliabilities above 99 per cent. Any ultimate reliability advantage of the solid unit would be reflected in a very small margin of increase over the liquid."

Solid propellant motors for drones, however, had their share of boosters. J. A. Crask of Astrodyne described a dual-thrust solid motor for the Teal drone which the Navy has used as a target for air-to-air missiles. This motor employs two extruded end-burning grains, the smaller for boost and the larger for sustained thrust, which together burn 8 min and provide a total impulse of 26,075 lb-sec at an altitude of 50,000 ft. The motor shows economical design. Problems of inhibiting the grains and insulating the motor case were solved with spirally wrapped pressure-sensitive aluminum tape and reinforced plastic liners, respectively.

Problems in Space

Those coming to grips with the engineering problems of space flight probably see drones as a carefree world. D. N. Buell of Chrysler Missile Div. tackled the problem of stress and strain caused by thermal gradients in a re-entry body. He took as an example a medium-range missile that develops a skin temperature of 1000 F and an average temperature of 200–330 F on an inside longeron. This temperature differential gives a difference of expansion greater than 0.045 in./in. Two such members rigidly joined will readily yield to thermal stresses alone. Buell shows that, for short periods, these structures, which stress calculations would normally reject, can be serviceable, and proposed that conventional margin-of-safety calculations be amended for such structures.

In the final session of the conference, A. F. Charwat of UCLA reviewed and compared the fundamental thermodynamic and propulsive properties of the turbojet, the ramjet, the rocket, and various combinations of these engines. He also offered a sound argument against the oxygen-recombination ramjet as a possible propulsion system for aircraft at very high altitudes, and drew attention instead of the isovolumic-isentropic combustion-expansion cycle as offering the possibility of increasing both the work-output and efficiency of an air-breathing engine. This cycle can be seen in the valved pulsejet, an example of which is the German V-1, and a device known as the "acoustic" combustor. Although taking working fluid from the air, these devices offer considerable static thrust, he noted.

Assisted-Take-Off Units

The de Havilland Engine Co. has adapted Spectre and Super Sprite liquid propellant rocket engines for use as assisted-take-off units for Britain's V-class bombers, making it possible for them to operate from medium-length air strips.

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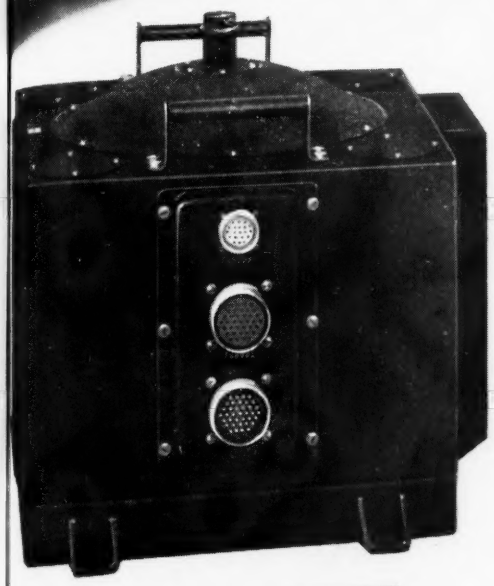

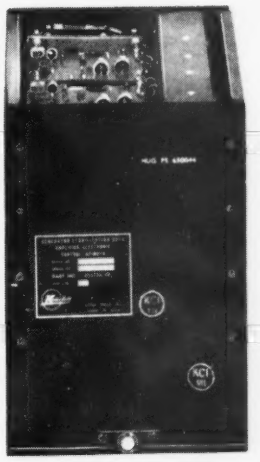

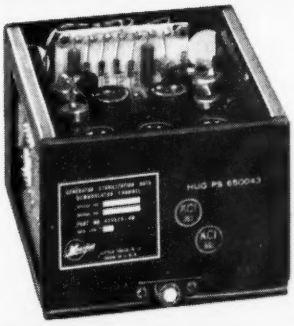

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in print

Vanguard! The Story of the First Man-Made Satellite by Martin Caidin, E. P. Dutton & Co., New York, 1957, 288 pp., illustrated. $3.95.

As the subtitle and many portions of this book indicate, it is a pre-Sputnik venture, with the result that many sections are already obsolete. The first two chapters and the last chapter, for example, describe a purported Vanguard launching as one of the most momentous events in history.

Having had some personal experience at Cape Canaveral, the author is able to describe it very well in his first chapter. Its desolate palmetto scrub and insects are still there. However, one wonders what has happened to the myriads of poisonous snakes and alligators which, according to the author, infested the scrub. No snake in his right mind would live in such a place. While this reviewer (and his colleagues) have yet to see more than one or two snakes, even in the scrub, he will step more gingerly from now on to avoid "a coral snake's lightning strike" or "the sharp fangs of a rattler." Maybe the snakes have emigrated, what with rockets crashing all over the place.

In Chapters 3 to 11, the author wanders through the mossy woods of other rocket projects, such as the V-2, Wac Corporal (Bumper), Viking and Aerobee. He makes a number of technical and spelling errors (Hagan for Hagen, etc.) throughout the book, especially with reference to Vanguard. He assumes, wrongly, that Stage I is a modified Viking and Stage II is a modified Aerobee-Hi. This comparison is as valid as one, say, which states that a Jaguar is a modified Mack Truck. Both have wheels and internal combustion engines, but that is all that is common to both.

His description of Stage II burnout is poetic, but incorrect, as is his sequence of Stage II–III spin-up and separation and the description of "combustion instability" in the engines which would affect the control system.

His eulogy of the Aerojet-General Corp. in Chapter 8 (Aerobee and Stage Two) is admirable but out of place, and looks like a public relations department release. In 20 pages of the chapter, only one paragraph deals with the second-stage propulsion system and this begins with an incorrect statement describing Stage II as a face-lifted Aerobee-Hi.

Chapters 9 and 10 are much better and describe very well the manufacturing steps involved in building the vehicle at The Martin Co. and the satellite at the Naval Research Laboratory, while Chapter 11 has a neat summary of the radio and optical tracking effort.

Chapters 12 and 13 are a rehash of some early rocket history, emphasizing satellite "dreams" of the past three decades, up to Wernher Von Braun's famous *Collier* series on space flight. Chapter 13 includes an exposé of the purported government happenings leading up to Vanguard. The complete story of U. S. space flight efforts and the background to Vanguard has not yet been told, either because of security or because no one knows it all.

Summary: Another space flight book.

Kurt R. Stehling
Naval Research Laboratory, Washington, D.C.

Man Unlimited by Heinz Gartmann, translated from the German by Richard and Clara Winston, Pantheon, New York, 1957, 214 pages, illustrated. $4.50.

"Man Unlimited" is a popular, lucid and dramatic account of the physical limitations of man pitted against the technological Frankenstein he has created.

Mr. Gartmann opens his book by impressing the reader with the ever-quickening tempo of progress. He develops the theme of speed as an example emphasizing man's inability to sense velocity as such. He studs this section with sparkling, imaginative analogies that make a serious subject forceful and clear. "If our arm were long enough for us to be able to reach out and touch the sun from our front doorstep, it would take us 65 years to be aware that we had burned our fingers!"

He then recounts with lurid descriptions in gruesome detail the trials and tribulations of human volunteer subjects who explore the limitations of human endurance. After experiencing the harrowing sensations of Colonel Stapp's sled ride, the torment of 6 *G* on a human centrifuge, bleeding under the stress of 15 *G*, the reader is more impressed by man's frailty than by his unlimited potentialities.

Following an overdramatized account of Chuck Yeager's and Scott Crossfield's encounters with weightlessness, he presents a most readable but occasionally distorted account of animal experiments and human experience with weightlessness to date. The conclusion of this chapter clearly analyzes the current situation: "The specialists in air medicine are going deeply into all aspects of the subject. They know that there is much to be learned but essentially little to fear. Man is already on his way to mastering the art of living in conditions of zero gravity."

Delightful anecdotes spice the account of Dr. Strughold's studies of the disturbance of man's rhythm of activity when suddenly displaced across many time zones.

The descriptions of the protection man needs for high altitude flight stimulate the imagination and clearly picture the principles of sealed cabins required for space flight. The physical nature of our atmosphere becomes a vivid fact. The problems of providing oxygen and a breathable atmosphere become an urgent challenge; the conditions on the surfaces of nearby planets familiar realities.

Presenting sound as a vicious adversary, the author dramatically portrays man's tolerance and intolerance to it and describes the machines spawned by the age of power as monsters to be silenced. The final chapters almost lose man among the shadows of his towering accomplishments in the newest fields of atomic energy and automation.

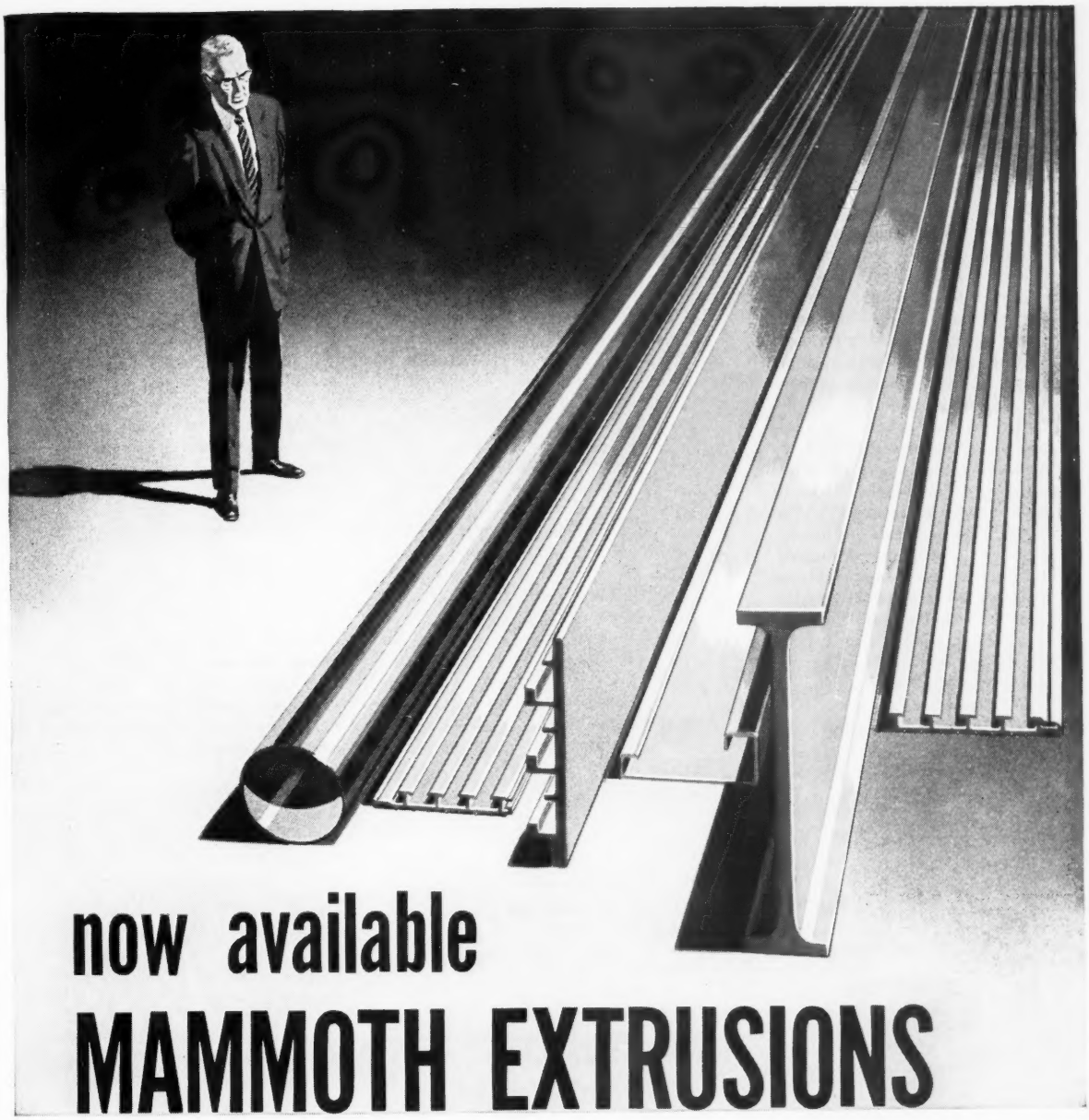
The true meaning of "Man Unlimited," better expressed in its original German title, "Starker als die Technik," is epitomized in a concluding paragraph: "When the shadows of the first atomic clouds fell upon the earth, when [frail] man ignited the fire of the stars, the fateful hour struck for us. We stood at the crossroads of humanity, and we sought an answer to the frightening question, 'Is this the end of a new better beginning?'"

For the true greatness of man lies not in the strength of his body, but in the stature of his achievements.

Maj. David G. Simons
Hollman AFB, N. Mex.

BOOK NOTE

Anyone with an interest in the uses of photography in missile research, will find **"High Speed Photography—Vol. 6"** (200 pages, Society of Motion Picture and Television Engineers, 55 W. 42nd St., N.Y.C., $3.50) a valuable addition to the reference bookshelf. Included in the volume is an article on a color Schlieren system for high-speed photography.



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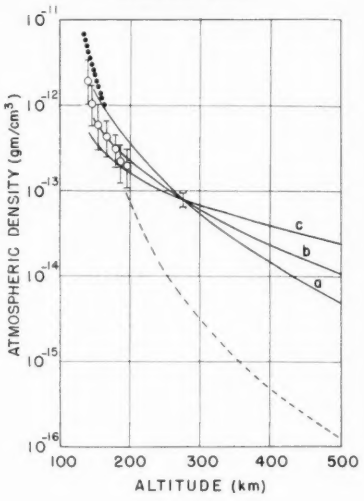
Sputnik I Provides Data on High Atmosphere

Analysis of Minitrack data on Sputnik I reveals a model atmosphere in agreement with recent data gathered by rockets on air density and temperature at altitudes up to 200 km and allows reasonable extrapolation of these measurements to 400 km, according to a recent report by I. Harris and R. Jastrow of the Nucleonics Div., U. S. Naval Research Laboratory.

Solid lines in the accompanying graph represent three model atmospheres that agree with the rate of change of the Sputnik I orbital period and fall within limits of probable error in rocket data up to 185 km. White circles on the graph represent rocket data, black circles related values from data on dissociation of oxygen. Dashed curve shows the ARDC model atmosphere, suggested by R. A. Mizner and W. S. Ripley in 1956.

The newly proposed atmosphere gives a satellite a much shorter theoretical lifetime than the ARDC atmosphere. Using the "b" curve on the graph, for example, a round satellite with a 10 kg mass and 50 cm in diam and an initial perigee and apogee of 400 and 1000 km, respectively, would orbit only 38 days, compared with about four years of the ARDC model.

UPPER ATMOSPHERE DENSITIES



A Smithsonian Astrophysical Observatory special report on Russian satellite observations advances a milder revision of the ARDC model.

Getting Missiles off to a Good Start

(CONTINUED FROM PAGE 31)

purpose, since pour points below −40 F can be obtained with mixtures of these substances.

In addition, after long storage, field problems may arise which make the furfuryl alcohol-aniline mixture unusable as a rocket igniter fluid. For instance, under field storage conditions, resinification occurs in furfuryl alcohol because of auto-oxidation and intermolecular dehydration. Intermolecular dehydration involves the splitting off of a molecule of water and the combination of two molecules of furfuryl alcohol. Further polymerization occurs, resulting in the formation of a resinous sludge. The reaction is accelerated by heat and by the presence of acid.

Furfuryl Alcohol Is Low Cost

This deterioration of the furfuryl alcohol in storage due to polymerization may be minimized by the addition of small quantities of aliphatic amines such as triethanolamine. Furfuryl alcohol is available in almost unlimited quantities at the relatively low cost of from 5 to 10 cents per lb. (It is manufactured commercially by the Quaker Oats Co. from a relatively abundant supply of furfuryl, which is derived from "waste" raw materials, such as corn cobs and corn stalks.)

Thus there are definite logistic advantages in using furfuryl alcohol in missile fuels when other requirements can be met. And it is used in a large Army Ordnance guided missile which requires approximately 2000 lb of fuel and 4000 lb of red fuming nitric acid as oxidizer. By blending 46 per cent furfuryl alcohol with 46 per cent aniline and 7 per cent hydrazine (by weight), a hypergolic fuel is obtained which proves satisfactory in this rocket motor both as a starting fuel and as a sustainer fuel.

The furfuryl alcohol-aniline-hydrazine fuel has good combustion properties and meets all other design requirements of the specific propulsion system, such as low freezing point, specific impulse, storability, and coolant properties necessary for regenerative cooling of the combustion cham-

ber walls. All that is necessary to ignite the bipropellants in this rocket motor is to inject them simultaneously into the motor combustion chamber. Spontaneous burning occurs instantaneously on mixing of the hypergolic fuel and oxidizer.

By gradually increasing propellant flow through a two-blade proportioning valve, the hypergolic fuel automatically becomes the sustainer fuel for maintaining a continuous combustion reaction. Prior to starting, fuel and oxidizer occupy the regular fuel and oxidizer feed lines leading to the injector manifold but are separated from the motor by two burst diaphragms. To start the rocket motor, regulated air pressure is supplied to both the oxidizer and fuel lines so that the separation diaphragms in the respective lines are burst and the two propellants allowed to flow simultaneously through the propellant control valve into the motor chamber. There they ignite on contact.

Unsymmetrical dimethyl hydrazine is being tested as a new starting fluid for igniting the JP-4 1-1 nitric acid bipropellants in another Ordnance missile. UDMH has many of the desirable chemical properties needed for a missile starting fuel. It can be stored longer than the furfuryl alcohol-aniline starting fluid because it does not deteriorate from polymerization reactions. It is highly stable and not easily detonated by shocks which may occur in field handling. It has a very low freezing point of about −70 F and will ignite readily at subzero temperatures with only a few milliseconds delay time.

UDMH is also less corrosive to ferrous alloys and more stable to oxidation than hydrazine. Any metal usable with hydrazine may also be used for unsymmetrical dimethyl hydrazine. Moreover, some low alloy steels and even mild steel may have limited use as construction materials.

Very Reactive Chemicals

Liquid hypergolic igniter fuels are a vital part of modern weapon systems now in operation. In general, they are very reactive chemicals designed to deliver large amounts of ignition energy in a short period—less than 50 millisec. Because of this reactivity, these fuels are often hazardous and must be fully understood by those required to handle them.

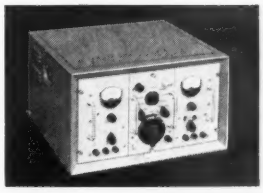
Once understood, they may be used safely and reliably to initiate the successful launching of a liquid propelled guided missile. And getting off to a good start can be as important as arriving at the destination, particularly since there is seldom a second send-off.

in tune with the tines*

Our friend Sherman's tuning fork technique has received extensive notoriety at many of the poshier type missile test centres throughout the land. Obstinate audile that he is, his attempt at aligning specific frequencies to assure accurate reception and transmission has led many a countdown into the wee hours. A pity, too, when one considers how perfectly our new Model 82 Signal Generator Series may be utilized as a pole beacon for missile checkout equipment. One power supply – six plug in r-f oscillators and you're in business all over the place.

The basic power chassis comprises both high and low voltage power supplies, a variable-amplitude (1 kc) sine-wave oscillator and a square wave shaper. Individual, interchangeable, r-f oscillator assemblies contain the remainder of the generator components: low frequency unit 20-80 mc, medium frequency units 300-500 mc, and four hi-freaks 500-1000 mc, 800-1100 mc, 1100-1600 mc and 2700-3000 mc. The people who use it say such versatility makes it truly unique among all other signal generators.

The Model 82 Series is *very* flexible plug-in equipment, taking up but a bit of the van racking space previously required for attuning telemetry and guidance channels, tracking and acquisition radar and voice links too. If you warm toward the 82 for missile checkout or even general laboratory measurements, be of inquiring mind—write for literature please.



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from the patent office

BY GEORGE F. McLAUGHLIN

Dual Jet Units Give Efficient Propulsion, Control Boundary Layer

Jet propulsion and turbojet power units designed to be efficient at any altitude and occupying small space within the wings of an airplane are the basis of a U.S. patent granted to a Swiss company. An added feature is that the air intake provides suction boundary layer control or other aerodynamic effects.

In the jet propulsion unit, a compressor producing the jet is driven by a thermal power engine in which a gaseous working medium circulates in a closed cycle. The cycle includes a compressor, tubular heating system, turbine and cooler. The jet issues through a nozzle near the wing trailing edge. Burners ignite fuel in the flow path of the air just ahead of the nozzle, increasing the thrust.

The turbojet power unit consists of a compressor, a combustion chamber and a turbine. The compressor supplies air to the combustion chamber which comprises nozzles for injecting fuel. Hot gas is supplied to the turbine which drives the compressor, and the turbine exhaust is directed by a nozzle as a propelling jet.

Compressed gas is heated in the tubular heating system by heat generated in the combustion chamber and supplied through a duct to the turbine where it expands while doing work. The turbine drives the compressor of the closed cycle thermal power engine and the compressor producing the jet issuing through the nozzle.

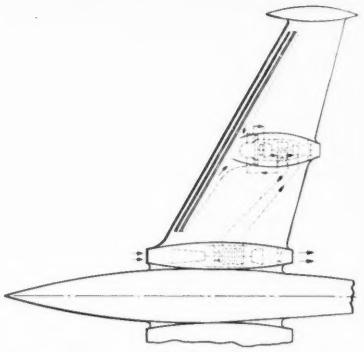
The expanded gas leaving the turbine traverses a plate type heat exchanger, and is then led through ducts to the cooler. The cooler is arranged in advance of the intake of the compressor in the flow path of the jet issuing from the nozzle. The closed cycle gas is thereby cooled by compressor intake air.

The cooled gas is then fed through channels to the compressor intake in which it is re-compressed and, after being pre-heated in the heat exchanger by the expanded gas, is again delivered through a duct to the tubular heating system, closing the cycle of the working medium.

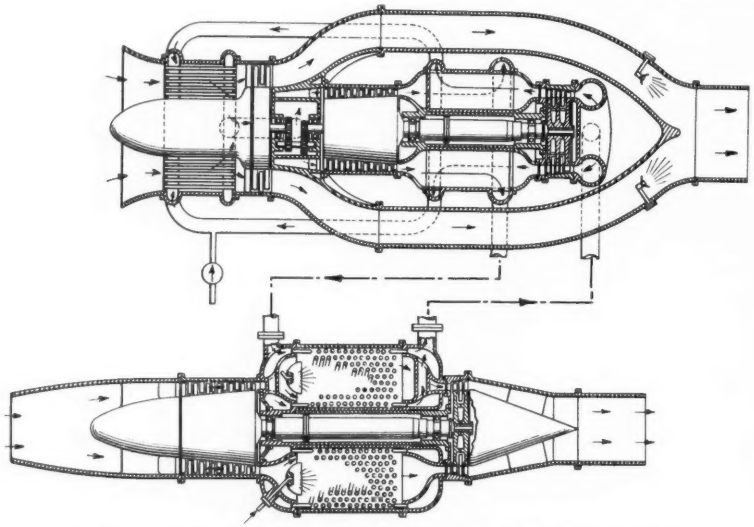
The heat exchanger comprises radial heat transfer plates which separate two series of alternating passages which communicate with manifolds. The first passages communicate at their inlet ends with the discharge from the compressor and at their discharge ends with the manifold, and hence with the conduit. The alternate passages comprising the second series communicate at their inlet ends with the turbine exhaust and at their discharge ends with the manifold.

Exhaust from the turbine exchanges heat with compressed air discharged by the compressor, so that the compressed air recovers heat from the exhaust of the turbine before receiving heat from the external source through the walls of the tubular system.

The jet propulsion unit is disposed in the wing and the air required to produce the jet is taken in through transverse apertures formed near the wing leading edge. These apertures serve to control the boundary layer by means of suction. Use of a jet propulsion unit to suck away the boundary layer is desirable because the development of long-range military and commercial aircraft leads to the use of boundary layer by suction for increasing lift.



Plan view of dual engines installed in the right wing of a jet airplane.



Sections of jet propulsion unit (top) and turbojet power unit.

It is advantageous to effect the heating in a modified combustion chamber of a turbojet power unit because such units must be operated with a large excess of air. The advantage is more pronounced in cases where compression ratio is high, so that oxygen aspirated by the compressor is almost completely discharged again. Therefore, it is expedient to burn more fuel than is normal in the combustion chamber, and to employ the liberated heat for the external heating of the working medium of the closed gas cycle. It is then possible to increase the performance without varying the operating state of the turbojet power unit. The increased pressure drop is partially offset by the greater expulsion of mass as a result of the increased fuel supply.

Closed cycle engines are relatively small. They utilize high pressures, and can be well accommodated in the very thin wings of high-speed supersonic aircraft. Also, elimination of combustion in such engines when housed in the wings results in increased safety.

Patent No. 2,820,599, (Dual unit jet propulsion plant for aircraft). J. Ackeret and C. Keller, Kusnacht, Switzerland, assignors to Aktiengesellschaft fuer Technische Studien.

JUNE 1958

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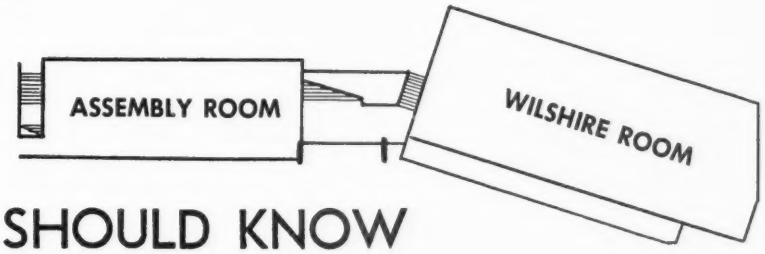

WHAT YOU SHOULD KNOW

about the 1958 ARS SEMI-ANNUAL MEETING — JUNE 8-12

- First national technical meeting ever devoted to *Experimental Engineering in Rockets and Missiles.*
- Twelve-session program will feature such subjects as:
  - Managing Experimental Missile Projects
  - Test Instrumentation
  - Propellant Handling
  - Handling and Testing Large Rocket and Ramjet Engines
  - Rocket Engine Systems
  - Missile Launching Operations
- Top quality papers are guaranteed by the fact that technical sessions are being organized by leading engineers in the missile business, men such as:

  Herbert L. Karsch, Aeronutronic Systems
  W. H. Pickering, Jet Propulsion Laboratory, Cal Tech
  Peter Weiser, Ramo-Wooldridge Corp.
  Krafft Ehricke, Convair-Astronautics
  John F. Tormey, Rocketdyne
  Brooks Morris, Marquardt Aircraft
  Y. C. Lee, Aerojet-General
  Lawrence Brown, Ford Instrument
  Herbert Friedman, Naval Research Lab.
  Mort Rosenbaum, Convair-Astronautics

- Featured luncheon and banquet speakers will be high officials in government, military, education and industry.

government contract awards

FMC to Build Thor Equipment

Food Machinery and Chemical Corp. has received a subcontract from Douglas Aircraft for an undisclosed number of ground handling and launching units for the Thor missile. The equipment will include an erector-transporter, launch mount and a power-pack trailer.

AF Awards Grant to Poly Tech

Polytechnic Institute of Brooklyn has been awarded a $50,000 grant from the Air Force Office of Scientific Research for a year-long study of combustion instability and scaling-up of rocket motors using liquid propellants.

Re-Entry Study

The Air Force has awarded Aeronutronic Systems, Inc., an experimental contract involving the study of gas interactions with the surface of an ICBM nose cone upon re-entry into the earth's atmosphere at hypersonic speeds.

Terrier Guidance Contract

The Navy has let a $26 million contract for guidance and control groups for the Terrier surface-to-air missile to Convair.

Atom Engine Study Contract

Rocketdyne has been awarded an AF nuclear rocket engine research and study contract under the administration of Wright Air Development Center of ARDC, and the AEC.

Propulsion Machinery Contract

The Navy has awarded General Electric a $6,360,341 contract to construct propulsion machinery—turbines, gears, generators—for three nuclear-powered fleet ballistic missile submarines.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formerly advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AIR FORCE

Aviation Supply Office, 700 Robbins Ave., Philadelphia 11, Pa.

Skids, missile handling, $34,265, **Consolidated Diesel Electric Corp.,** 880 Canal St., Stamford, Conn.

Commander, Hq AMC, Wright-Patterson AFB, Ohio.

Study program to integrate the F-86D weapon system into the continental air control & warning system, $91,945, **North American Aviation, Inc.,** International Airport, Los Angeles, Calif.

Three continuous centrifugal nitric acid purifiers, $53,629, **The Sharples Corp.,** 2300 Westmoreland St., Phila. 40, Pa.

Hq AF Missile Development Center, ARDC, USAF, Holloman AFB, N. M.

Satellite tracking and orbit determination system, $87,879, **Geo-Science, Inc.,** South Road, P.O. Box 1128, Alamogordo, N.M.

Liquid propellant rocket sled system, $225,000, **North American Aviation Inc., Rocketdyne Div.,** Canoga Park, Calif.

Cost overrun, $26,000, **Winzen Research Inc.,** 8401 Lyndale Ave., So. Minneapolis, Minn.

Cost overrun, solid propellant boosters, $135,000, **Phillips Petroleum Co.,** AF Plant No. 66, McGregor, Tex.

Rocket motors, $279,650, **Grand Central Rocket Co.,** Box 111, Redlands, Calif.

Rocket motors, $105,480, **Thiokol Chemical Corp.,** Elkton Div., Elkton, Md.

Hq AF Missile Test Center, ARDC, USAF, Patrick AFB, Fla.

Decommutation system, FM telemetry, $74,908, **Missileonics, Inc.,** Melbourne, Fla.

Design, development, and fabrication of Azusa service, test, transponders, $1,297,340, **General Dynamics Corp., Convair Div.,** San Diego, Calif.

Spare parts, $35,190, **Cubic Corp.,** 5575 Kearny Villa Rd., San Diego, Calif.

Hq AF Office of Scientific Research, ARDC, Washington 25, D.C.

Continuation of research on paramagnetic resonance of free radicals, $49,982, **Washington University,** St. Louis, Mo.

Continuation of research on supersonic combustion, $116,740, **Fairchild Engine Div., Fairchild Engine & Airplane Corp.,** Deer Park, Long Island, N.Y.

Hq Middletown Air Materiel Area, USAF, Olmsted AFB, Pa.

Liquid oxygen, $650,388, **Linde Co., Div. of Union Carbide Corp.,** 30 E. 42 St., N.Y.C.

Hq Rome AF Depot, USAF, Griffiss AFB, N.Y.

Sage data processing equipment, $1,303,419, **International Business Machines Corp.,** 590 Madison Ave., N.Y.C.

Hq Shelby AF Depot, Wilkins AF Station, Shelby, Ohio.

Trailer, aircraft missile engine, $542,334, **Air Logistics Corp., 3600 E. Foothill Blvd., Pasadena, Calif.**

San Antonio R&D Procurement Office, ARDC, USAF, Box 63, Lackland AFB, Tex.

Research on advance medical problems encountered in flight through the upper atmosphere and space, $32,000, **Southwest Research Institute,** 8500 Culebra Rd., San Antonio, Tex.

ARMY

Boston Ordnance Dist., Army Base, Boston 10, Mass.

Hawk missiles and components, $13,249,594, **Raytheon Mfg. Co.,** 1089 Washington St., W. Newton, Mass.

Cleveland Ordnance Dist., 1367 E. 6th St., Cleveland 14, Ohio.

Communications system for Jupiter, $131,000, **North Electric Co.,** Galion, Ohio.

Corps of Engineers, Office of the District Engineer, U.S. Army Engineer Dist., Tullahoma, Tenn.

Process control system for the supersonic circuit of propulsion wind tunnel, Arnold Engineering Development Center, Tullahoma, Tenn., $43,930, **CDC Control Services, Inc.,** Hatboro, Pa.

Corps of Engineers, U.S. Army, Office of the District Engineer, Jacksonville Dist., 575 Riverside Ave., Jacksonville, Fla.

Telemetry ELSSE and CZR camera pads, AFMTC, Patrick AFB, Fla., $130,388, **R. E. Clarson, Inc.,** 1930 13th Ave., St. Petersburg, Fla.

District Engineer, U.S. Army Engineer Dist., P.O. Box 1538, Albuquerque, N.M.

ABMA vertical launching facilities, White Sands Proving Ground, N.M., $550,997, **Allen M. Campbell Co.,** General Contractors, P.O. Box 836, Tyler, Tex.

Los Angeles Ordnance Dist., U.S. Army, 55 S. Grand Ave., Pasadena, Calif.

Feasibility study on anti-tank guided missile system, $35,995, **Aeronutronic Systems, Inc.,** 1233 Air Way, Glendale, Calif.

Feasibility study on anti-tank guided missile system, $39,853, **Gilfillan Bros.**

Inc., 1815 Venice Blvd., Los Angeles 6, Calif.

Corporal handling and launching equipment, $1,195,365, **Firestone Tire & Rubber Co.**, 2525 Firestone Blvd., Los Angeles 54, Calif.

Repair and spare parts for Corporal missile system, $378,551, **Gilfillan Bros., Inc.**, 1815 Venice Blvd., Los Angeles 6, Calif.

Rocket engines $231,000, **North American Aviation, Inc.**, 6633 Canoga Ave., Canoga Park, Calif.

Launching area items, $4,757,939, **Douglas Aircraft Co., Inc.**, 3000 Ocean Park Blvd., Santa Monica, Calif.

Replenishment repair parts for Corporal missile system, $25,284, **Gilfillan Bros. Inc.**, 1815 Venice Blvd., Los Angeles, Calif.

New York Ordnance Dist., 180 Varick St., New York 14, N.Y.

Design & development of inertial devices, $404,619, **Ford Instrument Co.**, 31-10 Thomson Ave., Long Island City 1, N.Y.

Production engineering services for the preparation of miscellaneous ordnance documentation for Nike-Hercules, $3,401,354, **Western Electric Co., Inc.**, 120 Broadway, N.Y.C.

Feasibility study of quasi-passive post-launch fire control technique, $26,842, **Avion Div., ACF Industries, Inc.**, 11 Park Place, Paramus, N.J.

Design, development and fabrication of circumferential welding fixture for Jupiter missile center section, $93,350, **Air Reduction Sales Co., Div. of Air Reduction Co., Inc.**, 150 E. 42 St., N.Y.C.

Redstone Arsenal, Huntsville, Ala.

Liquid oxygen, $106,080, **Linde Co., Div. of Union Carbide Corp.**, 2900 Cahaba Rd., Birmingham, Ala.

Continuation of research and development of large solid propellant engines, $399,995, **Thiokol Chemical Corp.**, Trenton, N.J.

Continued development, fabrication, loading and delivery of XM10 rocket engines, $68,266, **Thiokol Chemical Corp.**, Trenton, N.J.

Rochester Ordnance Dist., Sibley Tower Bldg., Rochester 4, N.Y.

Tank for missile, $123,554, **The Pfaudler Co., Div. of Pfaudler Permutit, Inc.**, Rochester, 3, N.Y.

Springfield Ordnance Dist., Springfield 1, Mass.

Accumulation and submission of data pertaining to re-entry of bodies into the atmosphere, $65,898, **Barnes Engineering Co.**, Stamford, Conn.

U.S. Army Engineer Dist., Philadelphia, 2635 Abottsford Ave., Philadelphia, Pa.

Architect-engineer services in connection with conversion of Nike-Ajax to Nike-Hercules, $36,049, **Sanders & Thomas Associates**, 1418 Walnut St., Phila. 2, Pa.

Architect-engineer services in connection with design for omissions and inadequacies program at 12 Nike sites in the Philadelphia defense area, $48,728, **Anderson & Casaccio**, 504 Sweed St., Norristown, Pa.

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U.S. Army Signal Supply Agency, 225 So. Eighteenth St., Philadelphia 3, Pa.

Additional research work for 12 months in the guided missile range instrumentation field, $182,355, **Aeronutronic Systems, Inc.**, Glendale, Calif.

NAVY

Navy Dept. Bureau of Ordnance, Washington, D.C.

Rocket, JATO, aircraft, solid propellant, $2,275,470, **Aerojet-General Corp.**, Sacramento, Calif.

Purchasing Office, Dept. of the Navy, Bureau of Aeronautics, Washington 25, D.C.

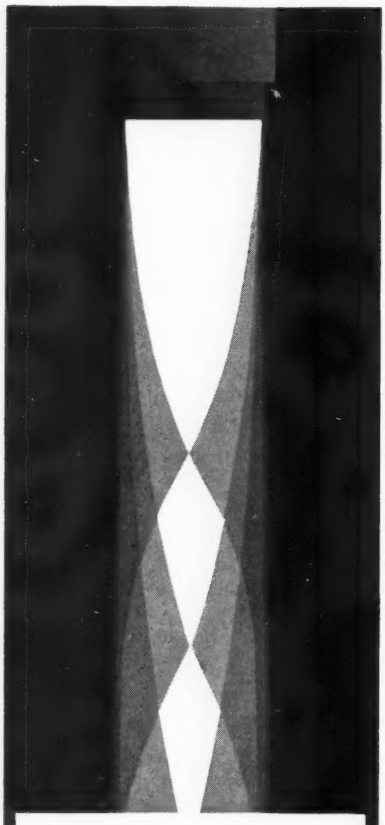
Model KDA-1 target drones, $7,062,858, **The Ryan Aeronautical Co.**, Lindbergh Field, San Diego 12, Calif.

Study of application of steel honeycomb and other elevated temperature cellular sandwich core material to the manufacture of aircraft and missile components, $99,812, **Stanford Research Institute**, Menlo Park, Calif.

U.S. Navy Purchasing Office, 1206 So. Santee St., Los Angeles 15, Calif.

Personnel, engineering, materials and facilities to assist in Talos program evaluation, $289,631, **The New Mexico College of Agriculture and Mechanic Arts**, State College, N.M.

Personnel, materials and facilities to conduct research in connection with Polaris program, $32,300, **Stevens Institute of Technology**, Hoboken, N.J.



PROPULSION

Long-range ballistic missiles and space vehicles impose unusually severe demands on the ability of current technology to achieve close tolerances and high performance. Examples of the stringency of these demands are found in auxiliary power supplies and in the monitoring of propellant consumption to obtain minimum burnout weight.

Auxiliary Power Supplies

Several positions are open for graduate engineers with five or more years of experience in rotating machinery development, and an interest in technical management responsibilities, including contractor liaison and test planning.

Propellant Utilization

Opportunities are available in project management of propellant system development for graduate engineers with extensive experience in aircraft or missile design and flight testing.

Inquiries regarding these opportunities are invited.

SPACE TECHNOLOGY LABORATORIES

A Division of
The Ramo-Wooldridge Corporation
5730 Arbor Vitae Street
Los Angeles 45, California

Laboratory for Space Research

(CONTINUED FROM PAGE 38)

heated. The suit inhabitant in the vacuum chamber can be likened to someone in a thermos bottle. In a vacuum, the only mode of heat transfer from surfaces is by radiation. No relief can be obtained by heat loss from the suit surface by radiation inasmuch as the chamber walls are at approximately the same temperature. Thus, induced cooling by circulation of the breathing oxygen at a low enough temperature is the method used to dissipate body heat.

For economic reasons, a closed breathing and ventilating system was incorporated into the suit system, with provisions for heat, moisture and carbon dioxide removal. Oxygen consumed in breathing is replenished by an automatic sensing device.

Very low external pressure on the body causes a number of disturbances. Circulatory vapor lock, caused when the blood turns to foam at low pressures, can block the blood flow to the vital organs in about 10 sec. In addition, distention of the abdomen and the "bends" (aeroembolism) occur with sudden exposure to low external pressures. As a result, it is necessary to pressurize the immediate environment surrounding the inhabitant.

The minimum allowable pressure for breathing and safety against the bends is approximately 3.5 psia, at which value the evolution of nitrogen in the blood stream is marginal. For additional safety, 5 psia pressurization was chosen for use in the Litton suit. However, a suit inflated to 5 psi is considerably less supple than a football, which is inflated to about 3 psi. The effort required to bend an inflated object is due to the work that must be done on the pressurizing gas, corresponding to a change in volume, i.e., $Fdx = Pdv$, or $F = dv/dx$.

To keep this force to a minimum or zero, and thus keep the required effort small, the design of moving parts in the suit demands a negligible or zero change in volume. Consequently, design of constant volume joints is of prime importance to minimize effort and reduce fatigue. Combined with the problem of minimum constraint is the problem of maintaining dexterity to allow the inhabitant to perform the normal functions of any researcher in writing, twisting controls, making adjustments and using small hand tools.

Suffice to say that over 50 per cent of the engineering effort which went into the design of the laboratory was devoted to the protective suit and suit system. Although the present suit is not designed for use in outer space, only some small modifications and refinements, plus provision for self-sufficiency in breathing and cooling, would be necessary to convert it to a space suit for satellite station assembly work or planetary exploration.

Most aviation full-pressure suits are designed as emergency survival suits, which must provide maximum mobility during normal operations, and only limited mobility in an emergency. Exposure to an extreme low pressure is calculated for only a short period of time. In addition, these full-pressure suits are invariably used in a pressurized compartment or capsule which provides a livable environment.

A researcher in the Litton laboratory, or the space traveler or planet explorer who has lost his protection through capsule failure, must be protected for long periods of time. The inhabitant of the Litton Laboratory has occupied the chamber under space conditions for periods over four hours.

Communication with the suit wearer in the chamber is maintained through wire connections feeding through the umbilical connection.

Safety System

In the event of a failure in the suit or in supporting mechanical or electrical equipment, survival of the inhabitant is the prime consideration. To this end, the safety system must provide:

1. A quick-acting pressurizing system to restore the inhabitant to tolerable pressure levels in the event of rapid decompression.

2. An auxiliary system, both pneumatic and electrical, for standby purposes, capable of immediate switch-over.

3. A system of monitoring the physiological factors which signal the condition of the inhabitant prior to and during the emergency.

The dangers resulting from failure in the protective suit, as well as the physical effects on the inhabitant, have already been indicated. These dangers and their resulting consequences fix the time-scale necessary to insure survival and minimum hazard to the inhabitant.

The emergency air system, auxiliary standby equipment and medical monitoring equipment have been specifically designed and chosen to meet any possible emergency. To preclude a mishap due to the human element, all safety procedures are automatic, and reliability has been insured by system redundancy. In addition, standard operating emergency procedures have been given careful consideration, and laboratory operating crew members have been rigidly drilled to handle individual duties for any emergency situation.

The laboratory is adaptable to any line of research or investigation where controlled low-pressure atmospheres are required. In fields such as electronics, chemistry or metallurgy, where operations in a vacuum are involved, the ability to vary experimental parameters, exchange components or adjust physical relationships without removal from the test chamber will accelerate research and test programs by several orders of magnitude and permit the use of design techniques hitherto considered impractical.

A partial list of the general areas and research programs which have immediate implications and interest include space suit and space capsule development; missile and satellite component environmental testing; thermal balance problems of space; vacuum tube technology; development and testing of ionic plasma accelerators; and basic physical research, such as the mechanics of friction and other physical properties of nearly outgassed surfaces.

The laboratory also provides a convenient test environment for development and testing of scaled prototypes which will furnish design data or establish environmental criteria for full-scale specialized configurations.

French Anti-Tank Missile Purchased for U.S. Troops

The French wire-guided Nord SS-10 anti-tank missile, a fully developed and tested system already adopted as standard ground armament by France, Sweden and Switzerland, has been ordered in quantity for the U. S. Seventh Army in Germany.

The SS-10, which bears a family resemblance to the U. S. Army Dart, is a small tailless aircraft with cruciform wings canted to give stabilizing spin, and powered by tandem solid rockets with concentric nozzles. One rocket boosts the missile to 260–295 fps in 0.5 sec and, through a flash port, ignites the second, which sustains flight for about 5000 ft. Because of the relatively high initial acceleration, the missile can be fired from a zero-length launcher held by a simple tubular frame.

The missile is controlled by yaw-pitch coupled spoilers set at the trailing edges of the fin roots; wire-delivered command signals; and a gyro, brought to speed in 0.1 sec by a solid propellant gas generator, which keeps the control-signal box aligned as the missile spins.

The SS-10 is 34 in. long and has a 30 in. wingspan; it weighs 33 lb.

11-35

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You are invited to write for more information or phone collect. Address R. W. Frost, System Development Corporation, 2400 Colorado Avenue, Santa Monica, Calif.; phone EXbrook 3-9411.

SYSTEM DEVELOPMENT CORPORATION

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Johns-Manville Min-K Insulating Material

Johns-Manville scientist demonstrates effectiveness of Min-K. High-temperature wax model missile placed on conventional insulating material (left) and placed over flame from gas burner melts down rapidly, while similar model placed on same thickness Min-K does not melt.

Johns-Manville Corp. has introduced a new type of thermal insulating material called Min-K (for minimum conductivity), claimed to be ideally suited for missile and aircraft applications where space saving is paramount.

Thermal conductivity of Min-K is said to be less than half that of conventional insulators and below that of "still air." Even more important, its conductivity decreases with lower atmospheric pressure and, consequently, at higher altitudes. At an altitude of 10 miles, for example, conductivity is said to drop by as much as 50 per cent in certain applications.

Exact composition of the material has not been revealed, but it is described as "a bonded structure reinforced with fibrous media" and containing some asbestos. Available in various forms, with properties encompassing a wide range of strength, thermal conductivity, density and temperature resistance, it is already being used in one operational missile. It can be used for extended periods of time at temperatures as high as 1300 F.

For missile applications, the material can be furnished in combination with reinforced plastic laminates which permit use at even higher temperatures. The material can be molded, and integral missile parts could be produced in this manner.

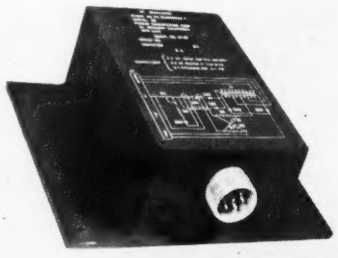
Johns-Manville scientists see Min-K giving missiles longer range and greater accuracy, since use of thinner sheets of insulating material will permit larger fuel capacity and provide better protection against the heat of combustion for guidance and control equipment. It is also being studied for possible use as nose cone insulating material.

•

Multi-Channel Data System: Magnasync recording and reproducing equipment for rocket engine testing and missile tracking employs perforated 35-mm magnetic film as the recording medium. Film is driven by a sprocket and synchronous drive motor to insure positive timing accuracy. Audio components are plug-in assemblies. Magnasync Mfg., Ltd., 5546 Satsuma Ave., N. Hollywood, Calif.

•

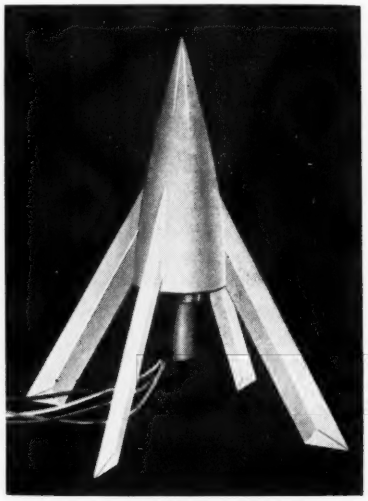
Welded Pressure Vessels: An R&D program has resulted in the development of welded titanium pressure vessels for storing many liquids and gases at extreme temperatures and high pressures with minimum weight. Welded pressure vessels of aluminum, steel and stainless steel alloys have also been produced. Applications include air and gas storage bottles for missiles and hydraulic system vessels for aircraft. Rheem Mfg. Co., Aircraft Div., 11711 Woodruff Ave., Downey, Calif.



AC Power Supply: Model M-786 is a special 400-cycle magnetic amplifier regulated ac power supply. It has an ac input of 108–121 v, single phase, 380–420 cps, with an ac output of 5.7 to 7.5 v at 2.5 to 5 amp, 400 cycle, one phase. Temperature range −40 to +150 F. Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

•

Temperature Measurement: Two new surface temperature transducers, Cement-On Type 1375, and Weld-On Type 1376 are platinum-resistance thermometers for installation on any surface. The protective cover of the resistive element is cemented or welded directly to the thermal surface, and forms an isothermal system which gives a true skin temperature reading.



Pitch-Yaw Indicator: The free-swiveling aerodynamic head of the model 4-1 indicator provides potentiometer output linear with angles of pitch and yaw. High temperature components permit operation at high Mach numbers. The indicator is available in ranges up to $27\frac{1}{2}$ deg, with an indicating accuracy of 0.1 deg. Metering is provided by two precision wire-wound potentiometers with single-wire function taps. Static or total head probes are available, either singly or combined. Edcliff Instruments, P. O. Box 307, 1711 S. Mountain Ave., Monrovia, Calif.

•

Zipper tubing: For use in electronic circuits of missiles and aircraft, Zippertubing is inexpensive, fast and easy to install. Designed to protect cables, wires and tubing from the corrosive effects of Skydrol and other hydraulic fluids, it may be used as a protection for existing wires, cable or tubing, or as a cable jacket or shield, and permits reaccessibility to work points. Zippertubing Co., 752 S. San Pedro St., Los Angeles 14, Calif.

Human Crews for Space Ships

(CONTINUED FROM PAGE 35)

ful today in flights measured in hours. Even allowing for improvements in reliability (and how do we build in the repair of, say, meteor damage?), there can be little doubt that such maintenance would be useful, not to say essential, in flights measured in terms of months.

Secondly, navigation—or rather, astrogation—can be greatly improved by human supervision. In addition, there will undoubtedly arise situations which cannot possibly be foreseen in advance. Very few computers do well with this type of problem. Men, on the other hand, are rather better suited for it.

It is also not unreasonable to assume that some of the crew will be scientists who wish to continue their experimentation in high vacuum-low temperature work. Most of the research which is possible on a satellite will also be possible on a space ship, and provision will probably be made for such research.

Remember, also, that there have been situations not unlike interplanetary flights in recent history. Wooden men-of-war, on blockade duty as recently as the Napoleonic Wars, for example, were entirely isolated for weeks at a time. The work was humdrum and routine, yet highly skilled. And, to add to it all, there was acute physical discomfort.

In many ways, spacemen will be better off. At least their beds will be dry, and if it is as dull as our present experts seem to think it will be, they will have enough sleep.

Historical Ancestors

Sailing a wooden square-rigged ship, while seemingly incomparably easier than piloting an interplanetary rocket, required what was, for the day, a very high degree of competence. Indeed, I could not do it now, and I doubt seriously if many of you reading this article would be able to keep all the masts erect if you were caught in a sudden squall with all sails set. Yet the work was, by and large, routine, and if any flavor comes through from the diaries of the officers on blockade duty, it is the flavor of boredom. The work was deadly dull. These men, however, survived.

In addition to the huge men-of-war with their crews of several hundred, there were small sloops which had perhaps 10 seamen and only three officers. Because of the social customs of the day, we might consider those three officers, so far as companionship is concerned, as the sole occupants of the ships. They survived, and came off quite well.

The point made here is not that there will not be problems involved. Selection of personnel, training crews —the whole job will be difficult. Considerable thought will be required to insure the sanity of crew members. They may well be bored, but we cannot believe that, simply because men are going, in small numbers, toward something unknown in an unfamiliar situation, they will go stark raving mad. If men were constructed that way, this country would still be inhabited by Indians.

Man Is Still Indispensable

In addition, it cannot be assumed that because we may be able to do without human operators, we ought to do without them. It will take a long time before we are able to construct a computer which can do all that a well-trained man can do. As a matter of fact, it may take an infinite number of years. What we must do is use our human operators effectively, to save weight and perhaps even to save rockets.

I think very few of us would be willing to trust an electronic captain to take charge of the Queen Mary. It hardly seems preferable to allow him to command the first manned Mars rocket.

Franklin Institute Gives Course in Astronautics

A series of 10 weekly lectures on space travel for laymen and college students is under way at the Franklin Institute in Philadelphia. The series, under the title of "10 Steps into Space," was arranged by I. M. Levitt, director of the Institute's Astronomy Div.

Willy Ley kicked off the lectures on March 4 with a discussion of the history of space travel. Other March lecturers and topics were: Kurt Stehling, NRL, "The Rocket and the Reaction Principles"; S. Fred Singer, U. of Maryland, "Satellite Instrumentation"; and Krafft Ehricke, Convair-Astronautics, "Space Navigation."

Future lecturers and topics are: Paul Herget, Cincinnati Observatory, "Celestial Mechanics"; Ernst Stuhlinger, ABMA, "Propulsion Systems"; Maj. David G. Simons, Holloman AFB, "Space Medicine"; H. W. Ritchey, Thiokol, "Rocket Fuels"; and Dr. Levitt, "Satellites and Travel in the Future."

Series fee is $10; individual lecture fee, $1.50. It is running through May 6.

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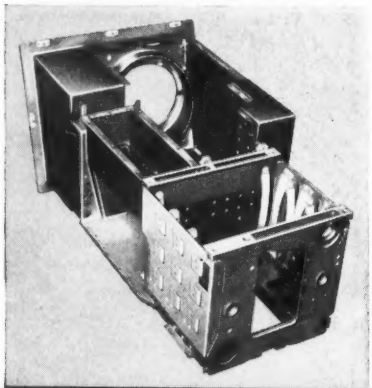

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Missile Market

(CONTINUED FROM PAGE 44)

the stock market. (It is almost exclusively the professional who goes in for short-selling, due to the amazing lack of understanding on the part of the general public as to this investment technique which in effect is no different than buying securities, except for the investor's opinion about subsequent price movements.)

In seeming contradiction to this indication of increasing professional bearishness many people will tell you that a large short interest is a very bullish factor. They go on to explain that the short sellers must cover (buy) eventually and that this represents a significant source of forced buying in the market which, of course, is bullish. The facts are right but the interpretation is wrong—a large short interest is bullish in only a very negative way.

Although it is true that buying will come into the market when short sellers take their profits this will only tend to slow momentarily the downward tide; it will hardly reverse it. A continued increase in the short interest figure, therefore, would tend to indicate that as the sophisticated Street professionals are increasingly bearish the market is indeed headed lower.

Some representative figures of short interests in certain leading securities are shown on page 44.

Another significant index, also released monthly, is the Securities and Exchange Commission's published changes in stock holdings of listed corporations' officers, directors and large stockholders. The latest report indicates that these "insiders" have mostly been selling if they have been doing anything. For instance: A top officer of Douglas sold 4000 shares, reducing his direct ownership to 6000 shares; a top officer of General Dynamics sold 8000 shares reducing his direct ownership in the company to about 2500 shares; a top officer of Thompson Products sold 5000 of his 12,250 shares. It is obviously significant to the small investor to closely follow this activity before committing his money as a member of the general public, although it is of course always possible that all of these "insiders" are selling for personal reasons completely unrelated to their opinion of the future value of their company's securities.

Still a further guide to investors on what professionals think about missile industry securities is revealed in the quarterly reports issued by mutual funds on their buying and selling activities in the previous three months. This information is readily available to interested parties. As an example, it is interesting to note that in the three months ended December 31, 1957, DeVegh Mutual Fund, Inc. *added* to its portfolio as new investments: 1500 shares of Douglas Aircraft, 1000 Lockheed, 6000 North American Aviation, 1000 Thompson Products, 2200 Air Products, 2000 American Bosch Arma, 7000 Raytheon, 1500 Varian Associates, 708 Mine Safety Appliances and 2000 General Tire.

Market Letter Gleanings

In early February, The Value Line Investment Survey published its industry analysis of the aircraft manufacturing industry. Included in this report were the following predictions on the potential market value of 17 stocks reviewed in the industry. This information is summarized below:

Company	Recent Price	Intrinsic Value Next 12 Months	Potential Value During 1961–63
Amer. Bosch Arma	21	19	32
Bell Aircraft	17	17	22
Bendix Aviation	49	49	70
Boeing	38	30	70
Curtiss-Wright	27	34	43
Douglas	65	60	97
Fairchild Engine	8	6.5	13
General Dynamics	61	47	78
Grumman	19	19	33
Lockheed	41	37	65
Martin	35	33	53
McDonnell Aircraft	26	23	51
North American Aviation	31	23	39
Northrop	23	20	32
Republic Aviation	19	19	33
Thompson Products	48	50	78
United Aircraft	36	56	94

Cal Tech Wind Tunnel Adopts New Digitizing System

An original method of obtaining force and moment test data in direct digital form has been selected for wind tunnel model studies at the Southern California Cooperative Wind Tunnel, operated by Cal Tech for five aircraft companies. Developed by BJ Electronics and Borg-Warner Corp., the digitizing system employs nine Vibrotron digital transducers and matched amplifiers to sense and signal hydraulic pressure variations from Emery load-sensing capsules directly attached to the test platform. Drag, lift and cross-wind forces and pitch, yaw and roll moments are computed by the data digitizing equipment.

Explorer I

(CONTINUED FROM PAGE 23)

ponents be mounted near the spin axis. The structure enclosing the payload was then designed in such manner as to minimize weight, consistent with overall reliability.

In the case of the Explorer I launching system, the design objective was to develop a system capable of reliability and economically putting into orbit the maximum mass. In order to accomplish this task within the prescribed time, judgment indicated the use of existing proved engineering developments. One significant example of this principle was the decision to use the solid propellant motors for the high-speed stages. The propellant grains for all of these units were fabricated at JPL, both those flown in the Jupiter-C RTV firings and those flown in the Explorer.

Over 300 Motors Were Tested

Over 300 motors had been tested statically, many under an accurate simulation of flight conditions, and no failures had been experienced. In addition, over 50 units had been flight-tested with no failures and with actual performance in excellent agreement with that predicted. Approximately 290 ignition systems of the type flown had been tested with no failures, and the reproducibility of operation was superior to that required for the Explorer mission.

Having decided to use these relatively small units, it was then necessary to group them so as to achieve optimum performance. A means of obtaining uniform performance from motor to motor was also necessary. The problem was finally resolved by judicious selection of propellant and loading technique and by accurate control of weights and weight distribution in each clustered stage. This is an example of the expediency of a simple design over that of a complicated design. In the latter, if all the intrinsic problems could have been solved, better performance might have been achieved.

A second engineering approach, used to a large extent, was the maximum utilization of engineers' experience in the minute details of manufacturing. The total malalignment of all components in the structure was precalculated with only experience as a guide. The alignment of the nozzle axis (thrust axis) to the center of gravity was defined from a combination of all of the expected malalignments of the individual masses and

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from their respective geometrical axes. Because the simple methods of measurement are less accurate than the alignments themselves, the results of these calculations were not measured as a summation for each motor. The best measurement techniques for calculating angular deviation from predicted flight paths, finding ocean impacts, or making orbital calculations have not shown errors in dispersion larger than the errors in the measuring systems. The alignment and design procedure enabled the assembly of a unit in the field with a malalignment of less than $^1/_{1000}$ in. for a large rotating mass. This type of accuracy can be reproduced after the stages have been disassembled and reassembled in the field.

In all cases where possible, dual or triple systems were used to prevent possible system failure caused by malfunction. For example, one problem which arose was the possibility that the igniter might have to be fired in a vacuum. The problem was resolved in three ways: (1) By designing an igniter which would fire in a vacuum; (2) by sealing the motor so that it held atmospheric pressure; and (3) by sealing the igniter in a container capable of holding atmospheric pressure. The last two designs carried with them a very small weight penalty.

Structural Design Criterion

Another possible problem area was in the local stresses under the attachment rings in the motor, used as pressure vessels. Elastic structural studies indicated that the design would fail; however, estimates of the plastic deformations in the materials led to the belief that the design was valid. The latter assumption was proved correct.

The structural design criterion for the strength of the propellant inside of the motor cases, which had their axes off the center of rotation, was one of deflection. The structural engineer actually stood on a short section of a motor case until the cross section was deformed the maximum amount; yet the charge did not crack nor separate from the motor case. Actual spin tests later confirmed the original findings.

Two necessary dynamic calculations were conducted: The critical spin rate of the whole high-speed assembly and the critical bend frequencies of the over-all missile. The difficulty in making these calculations is best shown by the fact that the original malalignment estimate, based on manufacturing experience alone, was one of the important parameters used.

One interesting design problem that arose was in the application of the aluminum oxide (Rokide) coating to the payload exterior. The original process consisted of cleaning the stainless steel surface by sandblasting and then applying Rokide in the normal manner. The surfaces that resulted from this treatment were not reproducible. Changes in surface characteristics could be traced to fingerprints, uneven heat treating, and difference in the grit size of the sandblasting. It was felt desirable to heat-treat the payload surface so that changes in the emissivity of the skin due to transient heating effects during the launch would be minimized. The process that was finally adopted required extreme care in the handling and heating of the sandblasted surface. The surfaces produced by this treatment were then tested for their respective low- and high-temperature emissivities.

In the inauguration of engineering designs, analyses must be conducted on both theoretical and statistical levels. As the design progresses, however, the maximum number of tests, time permitting, should be used. The problem of rotating-part design was also combined with static loads other than those in the direction of rotation. The test program had to use artificial means to attempt to combine loads, and some tests had to be conducted with only a portion of the loads applied.

One area of difficulty encountered was in the reproducibility of the cylindrical sheet metal sections of the motor cases. Heretofore, sheet metal had been purchased by the tolerances as specified by the fabricators in their catalogs. Upon closer investigation it was shown that, in any one mill run of material, the sheet was more uniform in thickness than the limits of the tolerance and that the sheet was slightly thicker in the center because of the deflection of the rollers during fabrication. It was also noted that when fabricating a motor with its length orientated to that of the original sheet there was much less bow in the motor case. This meticulous control of the fabrication enabled a high confidence level.

The payload for the Explorer satellite contains two minimal-weight radio-frequency transmitters. These transmitters were completely transistorized and designed in such a manner as to withstand all expected environments. Their power supply is a conventional chemical battery. In addition to the two transmitters, two separate antenna systems were provided, as well as proper sensing devices and electronic circuits to make the environmental and scientific measurements.

The two transmitters, although quite similar in electrical design, have different operating characteristics. They both operate continuously, and each carries four simultaneous channels of telemetering. One transmitter is a relatively high-powered unit radiating approximately 60 milliwatts of power into a turnstile antenna. This antenna consists of four wires perpendicular to the payload axis attached at the motorcase-payload joint. The information is transmitted in the form of amplitude modulation. The primary purpose of using this transmitter was to allow reception of the telemetering signals by the Minitrack receiving stations and by amateur radio operators. The measurements carried on this transmitter included two temperatures, the impact microphone output, and the continuous cosmic ray count.

Transmitter Lifetimes

The other transmitter radiates approximately ten milliwatts of power into a dipole antenna formed by electrically splitting the two halves of the payload. The insulator attaching the payload cylinder proper to the motor case formed the feed point for this antenna system. This transmitter also carries four channels of simultaneous telemetered information, although in the form of low-deviation phase modulation. The lifetime of this transmitter was intended to be approximately two months. The modulation on the carrier was recovered by Microlock receiving stations designed by JPL and operated both by the Laboratory and by British scientists cooperating at two overseas locations. The operating lifetime of the high-power transmitter was approximately two weeks due to its larger power requirement. The two transmitters were completely independent, having separate antenna systems, power supplies and telemetering oscillators.

The temperature was measured at four different locations on the satellite. Temperature was measured under the stagnation point of the nose cone for the purpose of determining the highest temperature experienced during the launch phase. Temperature was measured on two locations of the outside surface of the payload for the purpose of determining the temperature excursion and therefore the success with which the temperature of the satellite itself was controlled by surface preparation. The fourth temperature measurement was inside the instrumentation itself, located near the most sensitive transistor in the high-power transmitter. The two transmitters are located at the two extremes of the instrumentation compartment with the cosmic ray and meteorite electronic circuitry located at the aft of the forward transmitter.

Although the payload for the Ex-

plorer satellite was designed, developed, built, tested and flown in an 80-day period, it was based upon research that had been carried out at JPL over the last three years. This research included the development, design and testing of the Microlock transmitters that provided the radio signals from the satellite. A comprehensive environmental testing program was carried on, both during the long-term study program which led to the final transmitter design and after flight hardware had been built. This environmental testing included such items as response to spin loads, structural integrity against spin and thrust loads, behavior under severe vibrations such as would be generated by the burning rocket motors, and temperature cycling similar to that which was expected to occur under orbital conditions. Facilities were constructed to attempt to reproduce the environmental conditions in the laboratory. These included a vacuum chamber, with associated thermal cycling equipment to determine the thermal conductivity between the outside skin of the payload and the electronic instrumentation inside.

Thermistor Is Used

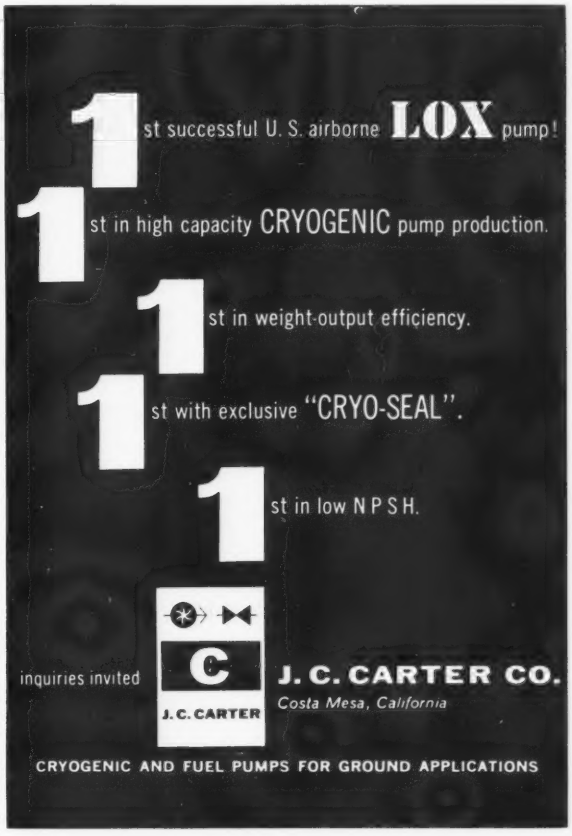
As has been mentioned previously, the experiments in the Explorer satellite consisted of several temperature measurements, the measurement of micrometeorite impact and of cosmic ray intensity. The temperature measurements were made by means of both thermistors and resistance thermometers. A thermistor was used for the internal temperature measurement of the high-power transmitter, and for one of the skin-temperature measurements. Resistance thermometers were used for the other skin-temperature measurements and for the temperature measurement of the nose-cone stagnation point. Conventional transistorized subcarrier oscillators were used in conjunction with these temperature transducers. Different sets of subcarrier oscillators were used with the two different transmitters.

The micrometeorite experiment consisted of an impact microphone, a microphone amplifier, and a scale-of-2 circuit. The scale-of-2 circuit was used to switch the frequency of one of the subcarrier oscillators between two given values. The observation of a frequency change of this subcarrier oscillator indicated a meteorite impact somewhere on the payload surface. A set of wire gauges for erosion measurements was mounted toward the aft end of the rocket-motor case, and wires were run along the side of the motor case to the subcarrier oscillator contained in the payload compartment. This subcarrier oscillator indicated changes in total resistance of the circuit composed of the eleven wire grids.

Cosmic radiation was measured by means of a Gieger-Mueller counter, an associated transistorized high-voltage power supply, and a scale-of-32 circuit. The output of the scale-of-32 circuit was used to control subcarrier oscillators in the same manner as just described for the impact microphone.

Standard RDB (FM/FM) telemetering channels 2, 3, 4 and 5, were selected for use in this experiment. The telemetering subcarrier allocation is listed in Table 1. The measurements that were carried on the various subcarrier channels, as well as the characteristics of the two transmitters, are listed in Table 2 on page 23.

The statistical distribution of the space density and the relative momentum of micrometeorites are quantities which are of importance from both a scientific and an engineering standpoint. The micrometeorite experiment using the wire grid was originally planned as part of the State University of Iowa IGY satellite experiment. However, in discussion with the Air Force Cambridge Research Center, which was responsible for this portion of the experiment, it became apparent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that an impact microphone could also be carried conveniently on Explorer I. This microphone could also contribute valuable data of a type quite different from that indicated by the wire grids. This measurement is of prime importance in the design of future satellites, as well as space vehicles.

The continuous cosmic ray intensity is being measured and telemetered by both transmitters. The purpose of this experiment is to measure on a long-term basis the change in cosmic ray intensity outside the earth's atmosphere. In addition, due to the nature of the satellite orbit, cosmic ray intensity change with longitude, latitude and altitude will also be measured in a band adjacent to the earth's equator covered by the satellite orbit. For the purpose of this experiment, it would be very fortunate if a solar storm should occur during the lifetime of the satellite instrumentation. Estimates of the expected counting rate indicated that the scaling circuit should divide the total count by approximately 32. The purpose of this was to enable amateur operators to record cosmic ray count in places on the earth where sophisticated recording equipment might not be available.

As for the launching mechanics, as mentioned previously, the modified Redstone first-stage vehicle was used to boost the high-speed motor assembly and payload to approximately orbital altitude. The Redstone used inertial autopilot guidance. Soon after burnout of the missile, the instrument compartment and high-speed assembly were separated from the Redstone proper. The spatial attitude control was used to pitch the high-speed assembly over into such a position that it would be parallel to the surface of the earth at apex of the Redstone trajectory. The operation and orientation of the instrument compartment and spatial attitude system were continuously telemetered through launching of the next stage. The trajectory of the instrument compartment was determined by several means on a real time basis. Using prepared nomagraphs, the exact point of apex was computed, based on radar, Dovap, and other data. When the apex had been achieved, a signal was sent by radio to the spatial attitude control system to fire the high-speed stages. An automatic timer was also employed. The high-speed assembly was spun to overcome thrust misalignments and burning-rate differences between clustered motors. Careful analyses of expected dispersion against spin rate had been made, and the final spin rate selected had been based on tolerable dispersion. Other considerations were the critical frequencies for the over-all configurations and for the spinning high-speed assemblies.

The payload weight was kept below the maximum allowable for a circular orbit. It was desirable to have some excess velocity to make up for possible launching inaccuracies. Since the over-all performance of the missile was not known with enough accuracy, excess performance was provided to overcome performance which might be below nominal. Lastly, it was desired to achieve an orbit that had a high degree of elipticity in order to gain the maximum of information about the dependence of cosmic ray intensity upon altitude. The over-all configuration was initially tested in September of 1956 when the first Jupiter-C missile was flown from Cape Canaveral, Fla. This first flight consisted of a Redstone booster plus the high-speed stages. It carried a dummy motor case for the final stage and suitable instrumentation in the payload assembly. As has been publicly announced, this flight went somewhat over 3000 miles and attained an altitude of approximately 650 miles. Among other instrumentation, the payload carried an early

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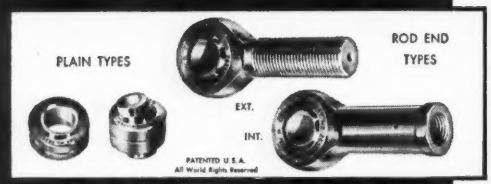

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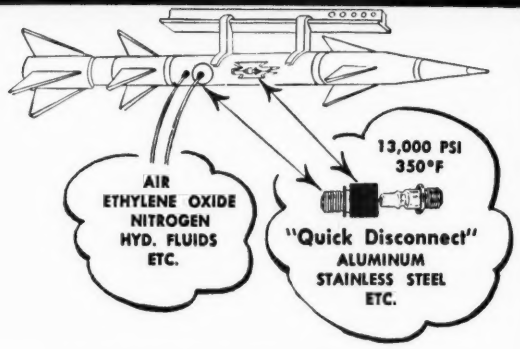

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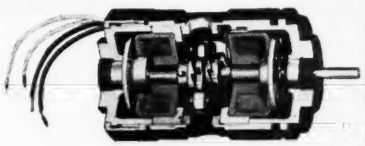

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model of the Microlock transmitter similar to the low-power unit presently in the Explorer satellite. At the time of the firing the Microlock ground receiving equipment was shown to be capable of tracking with a 10-milliwatt transmitter to over 2000 miles line-of-sight distance, at which point the payload disappeared below the radio horizon.

The choice of the Explorer I orbit was influenced by, among other factors such as payload weight, the desire for a relatively long lifetime. The criterion to be satisfied was that of achieving a predetermined perigee with a specified high probability. The statistical parameters were the mean values and standard deviations of propulsion performance and guidance accuracy and the assumed structure of the atmosphere.

The ability to make an early determination as to whether or not the satellite was in an acceptable orbit, using only relatively simple equipment and computational techniques, led to a detailed analysis of the information obtainable from the Doppler shift of the satellite transmitter.

The slope of the Doppler function at the point of nearest approach to the observer is given by

$$\left[\frac{V^2}{|\vec{r}|} + \vec{A}\cos(\vec{A}\dot{r})\right]_c^f$$

where V and $\vec{A}$ are the velocity and acceleration vectors of the satellite in a coordinate frame rotating with the earth, $\vec{r}$ is the vector from the receiving station to the satellite, f is the transmitter frequency, and c is the speed of light.

If θ is the angular distance on the surface of the earth and h is the height of the satellite above the surface, and if $\vec{A}$ is parallel to the vector from the satellite to the center of the earth, then the distance of minimal approach is

$$r_{\min} = \frac{f}{\text{slope at time of nearest approach}}$$

$$\{V^2 - |\vec{A}|[R_0(1 - \cos\theta) + h]\}$$

where R_0 is radius of the earth and

$$|\vec{A}| = g_0\left(\frac{R_0}{R_0 + h}\right)^2$$

and V can be estimated from injection data and the observed period.

Using information from the launching area, an estimation of perigee and apogee was made within 45 min of launch. This estimate was refined with the observations from a tracking-telemetry recording complex making simultaneous observations from Earthquake Valley, Inyokern (NOTS), and Temple City, all of which are located in California. A procedure based entirely on analog techniques was successfully employed by this group on the first pass to corroborate the initial appraisal. Five scientists and three girls to do the computing constituted the initial determination group. The group operating the complex was larger principally because of requirements of manning radio and telephone links.

The data received from Explorer I arrives at JPL in the form of digital Doppler print-out tape and magnetic tape.

The magnetic tape is simultaneously (1) dubbed from channels of interest, (2) digitally sampled, and (3) recorded by the analog computer on all four channels. The principal use of the latter is in evaluating the digital sampling. Information resulting from cosmic-ray observations is to be published by the State University of Iowa; on micrometeorite activity, by the Air Force Cambridge Research Center.

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